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TRAINING OF SOCIAL WORKERS

NOTWITHSTANDING the fact that many social workers have succeeded without taking a course in social studies at a university, it is an outstanding feature of training for social work in Great Britain that it has been developed largely as a branch of university education. Partly because this incorporation in, or connexion with, a university distinguishes British training schemes from those in most European countries (where special schools for the training of social workers have been established), and to a lesser degree from those in the United States (where independent 'trade schools' and schools affiliated to a university exist side-by-side), it is too often forgotten that those university courses which are to-day designed to provide a theoretical basis for a social worker's practical work had their origins outside the universities. Soon after its foundation in 1869, the Charity Organisation Society organised for its workers courses enabling them to train as almoners; and, so long ago as 1893, the Women's University Settlement in Southwark initiated courses of lectures for social workers.

When the courses arranged at the Women's University Settlement led directly to the foundation of the School of Sociology—which became in 1913 the Social Science Department of the London School of Economics—the question of the relation between theory and practice was immediately raised. In the report of the proceedings of a conference convened in 1902 to discuss the creation of the School of Sociology, it is recorded that there was a wholesome prejudice against mixing theoretical and practical training. It was, the report continues, regarded as "imperative that the teaching of the Universities should be free from any suspicion of bias in controversial matters. Their function was to train students in the observation of facts and the construction of theory from such observation. . . . It would be improper for the University to attempt to direct studies in their practical work, but it might be done in University Extension lectures and by lecturers specially qualified going from place to place."

As long as the number of social workers remained small and their activities circumscribed, the integration of theoretical and practical training remained a secondary issue. With the recent increase in the number of social workers and the extension of their activities, the profession has, in the opinion of Miss Eileen L. Younghusband, "reached the point of development when neither general social science courses nor purely professional training fully meets its needs"; and her "Report on the Employment and Training of Social Workers"* is a plea for experiment in improving the quality of training. The weaknesses of present methods are all too obvious. Although university courses are generally of a high academic standard, they are unquestionably weak on the practical side; and much professional training—which might, if properly orientated, make good this deficiency—is so weighted as to make no significant

* Carnegie United Kingdom Trust, Comely Park House, Dunfermline, Fife.

contribution to the general body of knowledge and adds little to the student's education in basic principles.

Although it certainly cannot be justified, the inadequacy of the part which is being played by many of the practical agencies engaged in training students can, in present circumstances, be explained. That those who carry out the day-to-day supervision of a student's work may themselves be trained or untrained may, or may not, be significant. What undoubtedly is significant is that they are not usually chosen because of some special aptitude for teaching students, that they have not normally been trained in teaching methods, and that they are compelled to regard the training of students as an incidental activity in the day's routine. It is therefore not surprising that Miss Younghusband finds "too little emphasis on the ethical and sociological issues involved in social work and on methods of helping people to help themselves. . . . Students are too often accepted because they are useful to the agency and not in order that a planned contribution may be made to the education of future social workers." It is, however, good to know that this critical attitude towards existing training schemes is shared by many social workers who are displaying "a tendency to stand back and look objectively at methods and a desire to seek guidance from their own best members and from outsiders in thinking out what they are trying to achieve".

That this discontent has not resulted in a spontaneous demand for the closer integration of theory and practice in university courses Miss Younghusband attributes to the clash of ideas which still exists regarding the function of a university and which was summarized so recently as 1944 in the two points of view expressed in the report of the McNair Committee on "Teachers and Youth Leaders". Those who favoured the joint board scheme declared: "If we may venture on a few general observations upon the functions of the Universities, we may say that in our opinion their main duty consists, and properly consists, in teaching basic subjects and in the advancement of knowledge". Opposed to them were the supporters of university schools of education who dissented strongly "from any sharp distinction between education and training, as though the one were the proper concern of the best institutions and teachers and the other were not". Rather did they express themselves as being concerned with training as "that part of the education of a student which emphasizes that he is preparing himself for a practical profession".

Nevertheless, as Miss Younghusband is well aware, the clash is academic rather than real. In providing courses for teachers and medical men the universities have long accepted the fact that they undertake vocational training. Where, perhaps, they have not accepted the responsibility thus incurred as fully as they might is in not always acknowledging the further fact that, having established such courses of training, they are logically committed to "testing the general suitability of those whom they admit, and whom they permit to complete the course and to emerge hall-marked with a professional qualification". Not the least of the merits of both the McNair and Good-enough Reports is their insistence on this point. As regards teachers, the former says that practical training in schools "should be so arranged that it enables a training institution to discover any students who are so clearly unsuited for teaching that they should be advised and, if necessary, required to abandon preparation for the profession"; and the latter, commenting on the selection of medical students, categorically insists that "however well-designed and conducted the training may be, it cannot produce successful results unless (1) in its organisation and conduct it allows for the full and active participation of the students, so that their education proceeds as much by their own efforts to learn as by their teachers' efforts to instil knowledge into them, and (2) the students are of suitable character and temperament and of an adequate standard of mental and physical fitness". Although Miss Younghusband quotes the passage from the McNair Report which postulates that "the personal suitability of applicants for entry into youth service is fundamental, and the institutions offering courses of training will keep continuously before them the need for devising the proper machinery of selection", she resists the easy—and obvious—conclusion that the quality of the training of social workers can be raised *merely* by increasing the vocational responsibility of the universities.

In this she is undoubtedly right. One result of the long separation—or, at best, partial integration—of theoretical and practical training is that the complexity of the problem has increased. There is, for example, no body of literature about the variety of human problems which make up the case or group worker's field of operation. Although, as she shrewdly remarks, it "could be continued indefinitely", Miss Younghusband's list illustrative of the need is in itself formidable: the highly sexed adolescent girl, the 'problem family', foster-home placement and adoption, 'unclubables', and the psychological factors involved in creating a community centre. Again, because it would be foolish to suppose that the closer integration of existing theory and practice would solve all training problems, there is the need for systematic inquiry and experiment. No attempt has yet been made to analyse the total content at which training courses should aim. Nor has it been decided what can most appropriately be acquired by lectures or discussion groups associated with lecture courses, or by working through illustrative cases, or by reading, work diaries kept by students, demonstrations, social surveys, visits of observation and actual practical work in different agencies. Miss Younghusband, who can speak with authority regarding the usefulness of the 'piecemeal and spasmodic' studies which are being undertaken, is emphatic that, if social work is to make any significant advance, a scheme designed both to promote research and to stimulate training must immediately be launched. Nor is she less emphatic that, as neither research will be promoted nor training stimulated "unless they are planned in relation to each other, and unless they are

generously financed over a period of years until they are so well established as to be able to stand on their own feet", nothing less will suffice than the creation of a school of social work.

Few, if any, would dissent from the view that such a pioneer institution "could do far more to raise the whole standard of training than some relatively slight improvement in methods in the various social science departments". Nor will there be many to dispute that a school of social work should be designed for four purposes: (1) to undertake research; (2) to run courses in the theory and practice of social work, leading to a post-graduate diploma, for suitable graduate and other students; (3) to provide general and refresher courses for social workers, teachers, Civil servants and others whose profession requires a knowledge of social conditions; and (4) to provide facilities for study for social workers from other countries. More controversial, however, are some of the detailed proposals. Should the school be a separate school of a university, analogous to the Institute of Education in the University of London? Can the purposes of such a school be met by courses extending over a period of fifteen months? Should the number of students be limited to not more than a hundred? Should part-time and evening courses be made available?

In formulating her own ideas on these and other questions, and incorporating them in the report as a basis for further discussion, Miss Younghusband has performed a useful service. Unanswerable as her arguments in favour of the creation of a school of social work would seem to be, the immediate implementation of such a scheme is clearly impossible. As Mr. E. Salter Davies says in a foreword which he contributes to the report, so large a project is outside the competence of the Carnegie Trustees during the current quinquennium. Nevertheless, it has not been placed on one side. The examination of the practical possibilities of the scheme has already been entrusted to a committee composed partly of members of the Carnegie Trust and partly of persons actively engaged in social work. This is a step on which the Carnegie Trustees are deservedly to be congratulated; and it may confidently be predicted that, whatever this committee may recommend as the first practical step, the publication of this challenging and scholarly report will mark the end of an era in which the term 'social work' has been used much too loosely.

THE UNION OF MATHEMATICS AND PHYSICS

Methods of Mathematical Physics

By Dr. Harold Jeffreys and Dr. Bertha Swirles Jeffreys. Pp. ix+679. (Cambridge: At the University Press, 1946.) 63*s*. net.

A CENTURY ago or more, the study of astronomy, mechanics and physics was one of the most potent factors in the origination and development of new branches of pure mathematics. Men like Euler, Cauchy, Hamilton and Gauss were keenly interested both in natural philosophy and pure mathematics, and there was often a fruitful inter-connexion between the two parts of their work. With increasing specialization, the exponents of the two sciences tended to drift apart, and relatively few continued to cultivate both. The pure mathematicians went forward into regions whither few physicists of the time were able to follow them, and indeed most physicists regarded any such attempt as futile for their purposes.

The physicists, moreover, found an immense amount of valuable and interesting pioneer and development work in their laboratories, requiring little mathematical knowledge and skill. Even on the theoretical side, much of their work consisted of hypotheses of limited range, requiring only elementary mathematical development. A few men of exceptional insight, like Riemann, Maxwell, Boltzmann and, later, Einstein, were not content with this piecemeal science, and sought a wider synthesis. Maxwell ("Coll. Works", vol. 2, p. 419), criticizing the procedure current in the theoretical physics and chemistry of his time, wrote thus:

"In attempting . . . the explanation of chemical phenomena, we have to form an idea of the configuration and motion of a number of material systems, each of which is so small that it cannot be directly observed. We have, in fact, to determine, from the observed external actions of an unseen piece of machinery, its internal construction.

"The method which has been for the most part employed in conducting such enquiries is that of forming an hypothesis, and calculating what would happen if the hypothesis were true. If these results agree with the actual phenomena, the hypothesis is said to be verified, so long, at least, as some one else does not invent another hypothesis which agrees still better with the phenomena.

"The reason why so many of our physical theories have been built up by the method of hypotheses is that the speculators have not been provided with methods and terms sufficiently general to express the results of their induction in its early stages. They were thus compelled either to leave their ideas vague and therefore useless, or to present them in a form the details of which could be supplied only by the illegitimate use of the imagination."

Maxwell went on to indicate where and how a better way was to be found. "In the meantime the mathematicians, guided by that instinct which teaches them to store up for others the irrepressible secretions of their own minds, had developed with the utmost generality. . . ." His particular reference was to the general theory of dynamics, developed by Lagrange, Hamilton, Jacobi and others, which in our time has proved marvellously apt as a basis on which to build the new edifice of quantum mechanics. In the same way, the recondite geometrical and analytical researches of Riemann, Christoffel and others (in their day "to the [applied mathematicians] a stumbling block and to the [physicists] foolishness", to vary St. Paul's words) provided the tool needed by Einstein in developing his theory of general relativity and gravitation.

In this and other instances the history of modern physics confirms Maxwell's views. Great as are the achievements possible to the non-mathematical experimenter gifted with genius, the development of a true natural philosophy, a wide-embracing synthesis, requires the union of great mathematics with great physics.

To check the diverging drift of physics and mathematics into realms with different languages and interests, and to aid the physicists who realize the

need for a combination of both, Courant and Hilbert as mathematicians produced in 1924 the first part of their famous work "Methoden der mathematischen Physik"; Part 2 followed in 1937, and together they form a great compendium and exposition of well-chosen domains of pure mathematics, valuable and relevant to physics.

Their example has now been followed by another such synthesis, worthy to bear comparison with that great predecessor—a British work, by two authors who are doing research and teaching mathematics in the University of Cambridge, and published in attractive form by its Press. Though consisting of one volume only, of manageable size, its content is about a third larger than that of Courant and Hilbert, with a word space of about 450,000 as against 350,000, though, of course, in each case much of this space is taken up by displayed formulæ.

A detailed comparison of the two books would be of great interest but cannot be undertaken here. Naturally, a good deal of ground is common to the two works; but there are also great differences of treatment and choice of material. In both works (and more particularly in the German one) the index is inferior in execution to the body of the work, and somewhat more effort spent upon it would have much helped the reader. But a comparison of the authors' names cited in the two indexes shows that the possession of Courant and Hilbert by no means renders superfluous that of '2*J*'—if one may modify and adapt, for the sake of a short and euphonious name of this book by Prof. and Mrs. Jeffreys, the familiar nomenclature (W^3) used by many mathematicians for "Modern Analysis" by Profs. Whittaker and Watson. It is safe to predict that '2*J*' will stand alongside 'W^3' as a treasured possession on the shelves of many physicists.

Among the distinctive and attractive features of '2*J*' are the initial chapters on the real variable, and Chapter 9 on numerical methods. Prof. Jeffreys' earlier monographs on operational methods and on Cartesian tensors are incorporated in other chapters. As in his volume "The Earth", the chapters are headed by quotations, the aptness of which is apparent in many cases. The chapters end, not, as in Courant and Hilbert, with references to further literature, but, in English fashion, with examples on which the reader can test his skill and his mastery of the text.

The book is well written, and the 'joins', if any, between the work of the two authors have not been detected by the reviewer. The severity of the subject-matter is occasionally lightened by touches showing the personality of the expositor. The book is a worthy addition to the great series of 'Cambridge Blues'.

FOLKLORE ON THE FARM

The Farmer's Friend or Wise Saws and Modern Instances

Being a Collection of Country Sayings. Compiled and commented upon by W. S. Mansfield. Pp. xiii+107. (Cambridge: At the University Press, 1947.) 6*s*. net.

PROVERBS, saws and trite sayings entered very largely into the conversation of countryfolk of old. In old-time Somerset, a couple of knowing heads would often wag over the stile and two pairs of wise old eyes would peer through the lofty hedges at the snowy masses of fragrant apple-blooth, flushed with a faint pink Alpine glow. "A good cider year, please God!" "Please God!" comes the echo. "Thof a proud spring d' often get his comb cut!"

Mr. Mansfield's collection of sayings, most of which he has gathered directly from farmers, has been produced in an attractive format, with four charming and appropriate illustrations by John Hookham. In the first place we may comment on the numerous references to seasons of the year and even to characteristics of particular months. In the present age, when the bulk of our population no longer lives in close touch with Nature, many of these sayings will appear cryptic; but here Mr. Mansfield steps in with crisp explanations that cast light on the most recondite statements. For example, "If you see grass in January, Lock your grain in your granuary"; because premature growth is usually cut back by the return of cold weather. Again, "What grows in May should be eaten in May"; because the young and leafy May grass, with its high nutritive value, if under-grazed, will become woody and indigestible in June. Some of the older sayings of the months, no longer current, might be harder to interpret, as they often contain obsolete words. Thus, John Aubrey, the seventeenth-century antiquary, mentions a Wiltshire saying, "Sowlegrove sil lew" (February is seldom mild). "The vulgar in the West of England," he says, "doe call the moneth of March, *Lide*"—a word we find in the old rhyme: "Eate leeks in Lide, and ramsins in May, And all the year after physicians may play".

These obsolete words show the great age of some of the sayings, and illustrate the faithfulness of oral tradition among the English peasantry. Mr. Mansfield quotes, "An eldern stake and whitethorn ether, Will make a hedge to last for ever". Here, in 'ether' or 'edder', we have a word going back to the days of King Alfred: it refers to the twisted wands of a laid (or 'plushed') hedge. Eldern stakes, it used to be said in the West Country, will outlast in the ground an iron bar of the same size. Another western adage embalming a close knowledge of the characteristics of trees tells us that "A withy tree will buy a horse before an oak will buy a bridle and saddle": the willow is noteworthy for rapid growth.

In a short introduction of much charm, Mr. Kendon points out that modern agricultural research does not always bear out the truth of the adage; but more often than not these old sayings, preserving the accumulated experience of generations, are fundamentally sound. "Copper under heather, silver under gorse, gold under bracken": Mr. Mansfield shows that the experience of War Agricultural Committees has amply confirmed the truth of this picturesque saying. One must confess, however, that upon occasion there is an ambivalent quality in some of these expressions. Thus, "The master's foot is the best manure" inculcates the need for incessant watchfulness and industry on the land; but on the other hand, Jan Ridd tells us in "Lorna Doone" that—leastways, in Somerset and Devon—"God makes the wheat grow greener, While farmer be at his dinner".

A characteristic epitome of rural wit and wisdom is to be found in one of Mr. Mansfield's items which says that "He that buys land buys many stones, He that buys flesh buys many bones; He that buys eggs buys many shells, He that buys good ale buys nothing else". It is perhaps scarcely in keeping with old-time rustic thought to suppose, however, that the

last sentence casts any reproach at the ale-bibber. The meaning seems rather to be that he who buys ale pays for no waste material, except perhaps for the last few drops in the cup which he sprinkles on the ground as a libation to a long-forgotten pagan deity commemorated in the traditional expression, "A drop for the wold Heark !"

Such sayings as we find in this intriguing collection range over the whole gamut of rural experience, and are by no means confined to observations on seasons, weather, birds, beasts, crops, trees, and the like. The human element, for example, is evident in such sayings as, "One boy is a boy, two boys are half a boy, and three boys are no boy at all"—a profound truth which holds in the laboratory as fully as in the field. Perhaps latter-day conditions will give rise to a similar saying in which the one, two and three boys are replaced by Greenwich time, summer time, and double summer time !

One final example, drawn from the reviewer's own experience, may be given as a masterpiece of terse expression. A Somerset farmer of the old school had been listening silently to a discussion on strikes and strikers. His opinion was asked. He removed his pipe, and as the adjacent cider-cup rose to its appointed place he let fall the memorable judgment : "Ah . . . Laziness idden wo'th much 'ithout 'tis well vollied !" JOHN READ

SCIENCE AND LIFE IN THE WORLD

Science and Life in the World

The George Westinghouse Centennial Forum, May 16, 17 and 18, 1946. (Whittlesey House Publication.) Vol. 1 : Science and Civilization ; The Future of Atomic Energy. Pp. ix+152. 12*s*. 6*d*. Vol. 2 : Transportation—a Measurement of Civilization ; Light, Life and Man. Pp. ix+236. 12*s*. 6*d*. Vol. 3 : A Challenge to the World. Pp. ix+198. 12*s*. 6*d*. (New York and London : McGraw-Hill Book Co., Inc., 1946.)

ON May 16, 17 and 18 of last year a significant gathering of men of science and leaders in the worlds of education and industry met at Pittsburgh to commemorate the hundredth anniversary of the birth of George Westinghouse, one of America's most renowned inventors and industrialists. Twenty-four prominent men in the field of science and technology were invited to participate in a notable symposium which summarized a great deal of our current scientific knowledge and pointed the way towards future research and development. A verbatim transcription of the addresses given on this occasion, together with illustrations including photographs of all the speakers, have been collected to make the three volumes reviewed here. As is to be expected, there is a wide variety of style, treatment and informative content in the different discourses.

The proceedings of the first day opened with an address on scientific ethics by Prof. A. V. Hill, foreign secretary of the Royal Society, who provided the link between the diverse matters which were considered after this. His thesis was that "the conditions of survival of man as a biological species and of his civilization involve a totally new factor in biology, the use of organised reason and accumulated knowledge. It was that which made the various civilizations possible and its perversions helped at intervals to bring them to an end." He is followed by Dr. Isaiah Bowman, the president of Johns Hopkins University, who speaks on the social composition of scientific power, and together with Dr. V. Bush, whose subject is "Planning in Science", provides a useful outline of the social aspects and possibilities of science. The latter part of the first volume is devoted to atomic energy.

Prof. J. R. Oppenheimer, who was in charge of the Los Alamos laboratory where the first atomic bombs were made, is rather inhibited by the demands of security, though he has some useful things to say and speaks with authority ; whereas Prof. E. Fermi, who constructed the first atomic pile, is less restrained and gives an account of the development of the pile, of which those at Hanford produce energy in amounts comparable with that of the largest hydro-electric plants. The applications of the new atomic discoveries to biology and medicine are dealt with by Dr. E. Chamberlain ; and Dr. Hugh S. Taylor of Princeton, who is perhaps best known in Britain for his catalytic phase-change method of separating heavy water, gives a short and simple statement of nuclear science in chemistry.

The first part of the second volume is concerned with the problems of transport, particularly from the American point of view. The scientific organisation of shipping, aviation and road transport is considered by various American experts in terms of economics, speed and convenience. The chapters should prove to be valuable to those who have to cope with the differing conditions in Great Britain and Europe ; but of most interest to the sociologist and layman is C. F. Kettering's paper on "The New American Way of Life" due to the development and popularization of the automobile. The book concludes with an excellent section entitled "Light, Life and Man". The various papers deal with biological warfare, photosynthesis, genetics with particular reference to artificial mutants and the recent work on moulds and enzymes, and Dr. Linus Pauling's investigations on molecular architecture in relation to biological reactions.

The third volume is an interesting mixture which shifts kaleidoscopically from one topic to another. There is a verbatim report of a broadcast brains trust, "Science, Salvation or Destroyer of Mankind", in which Dr. Urey has much to say. Also, we find an illustrated 'conducted tour' of the Buhl Planetarium and Institute of Popular Science at Pittsburgh. Accounts are also given of demonstrations in microbiology and crystallography using the optical apparatus at the same institution. There can be no doubt that good optical aids are an asset to the effective teaching of 'background' science. There follows a description of a visit to the Mellon Institute with its research work in plastics, petroleum and metallurgy. The volume also includes a number of short papers on the future of science as an aid to mankind, and Karl Compton's address on science "as an assurance against aggression and depression". The book ends fittingly with a short biography of George Westinghouse (1846–1914) by L. M. Stark. A detailed account is given of his invention of the air brake and the development of the turbo-alternator in the United States.

It is to be hoped that many more symposia on the broader social and ethical aspects of science will be held in various parts of the world, and that they will be reported as effectively as is done in these three admirably produced books. W. L. SUMNER

Calculating Machines

Recent and Prospective Developments and their Impact on Mathematical Physics; Inaugural Lecture. By Prof. D. R. Hartree. Pp. 40 + 2 plates. (Cambridge: At the University Press, 1947.) 2s. net.

THE rapid development of large-scale, high-speed calculating machines which has taken place in the United States in recent years is still not fully appreciated in Great Britain. These machines, in one form or another, are embodiments of Babbage's idea of an "analytical engine", and will undoubtedly have important effects both on numerical methods and on the attitude of the mathematical physicist to his problems. There is as yet no machine of this kind in Britain, though one is being planned at the National Physical Laboratory. The number of people from Great Britain who have seen the American machines is less than a dozen, and of these only one, Prof. D. R. Hartree, has actually worked the E.N.I.A.C., the electronic machine constructed at the University of Pennsylvania. This little book, therefore, has a particular importance. In this reprint of his inaugural lecture Prof. Hartree describes the E.N.I.A.C., and gives an account of the use he made of it in the solution of a set of non-linear differential equations with a two-point boundary problem. This gives him an opportunity to demonstrate vividly the remarkable speed of this type of machine, and to consider what features are desirable in such machines for general use in the field of mathematical physics.

The final section discusses the impact of these new developments on mathematical physics. The author suggests that not only will new mathematical developments be needed to devise new computing methods, but also that a new attitude to the problems of mathematical physics will be needed to make the best use of the facilities offered by this new type of equipment. In the author's own words, "It seems then quite possible that the facilities offered by these new calculating machines will at least make the formulation of physical problems in terms of integral equations and variation equations more familiar, and may in time wean us from our present tendency to regard a differential equation as the basic way of formulating the mathematics of physical problems".

Chemistry for our Times

By Elbert Cook Weaver and Dr. Laurence Standley Foster. Pp. xii+738. (New York and London: McGraw-Hill Book Co., Inc., 1947.) 12s. 6d.

THE authors of this new elementary text-book aim at relating chemistry to everyday life, beginning with the immediate environment of the pupil and progressing from more to less familiar experiences. The basis is experimental, although modern theories, including very recent advances, receive adequate attention in their proper places. A special feature of the book is the wealth of illustration, all kinds of industrial plants being shown, as well as striking diagrams and very neat perspective drawings of apparatus. The text is well thought out, suitable revision being introduced from time to time, and the style is clear and attractive. Some organic chemistry is included. Problems are postponed until late, and the questions at the ends of the sections are aimed at stimulating thought rather than being tests of memory. Many anecdotes of the personalities of great discoverers are given, and the international character of science is well emphasized.

Although the book is elementary it is by no means superficial, a large amount of sound information being given in an interesting way; and care has been taken throughout to make the text intelligible and clear to any reader. We think any boy or girl beginning the study of chemistry would be interested by this book, and it could very usefully find a place in any school or public library. The authors are to be congratulated on the result of what must have been a difficult piece of work. There are very few matters which should be altered in future editions, but among these it may be suggested that the information about the explosive properties of mixtures of hydrogen and air should come before, rather than after, the description of experiments with this gas; the date of Black's discovery of fixed air is twice given as 1775 instead of 1756; and the god Aeschylus in Fig. 21–21 should surely be Aesculapius. The very moderate price of the book is most commendable. This is an excellent elementary text-book which brings the modern developments in discovery into relation with classical material in a very skilful way.

X-Rays in Research and Industry

By Dr. H. Hirst. Second edition. Pp. vii+124. (London: Chapman and Hall, Ltd., 1946.) 13s. 6d. net.

EXCEPT for minor corrections, this book is identical with the first edition published in Australia and reviewed in these columns a few years ago. The book provides a concise introduction to the technique of X-ray diffraction and radiography, and to its applications particularly in physical metallurgy. An outstanding feature is the detail with which the author describes the practical details required by the experimenter, and it is to the practically minded reader that the book will most appeal. Every technique is not covered; but sufficient of the standard techniques is given to allow any worker entering this field to make a useful beginning. Since the first edition, other books have appeared which treat the same field of X-rays and metallurgy in a much more comprehensive manner. The present book will be found helpful, however, as a very readable and succinct introduction to these larger treatises.

W. A. WOOD

Psycho-Analysis and its Derivatives

By Dr. H. Crichton-Miller. (Home University Library of Modern Knowledge, No. 164.) Second Edition. Pp. 272. (London, New York and Toronto: Oxford University Press, 1945.) 3s. 6d. net.

THIS small book, which has deservedly been a very popular one, gives a strong, straightforward and simple account of the theories of the different schools of psycho-analysis. The three chief schools of Freud, Jung and Adler are all discussed in detail, and Prinzhorn added to them. The writer considers Freud's the most intricate, Jung's the most profound, Adler's the most practical and Prinzhorn's the broadest. Adler's system, of course, owing to its simplicity, attracts a great deal of attention, possibly owing to the appeal of the so-called 'inferiority complex' and of the fact that Adler pays little attention to dreams. Prinzhorn's use of lay analysts almost without limit to their activities is open to criticism, but may, because of this, appeal to a large number of people. There is a brief note on developments along various lines, and some account of Stekel's work published in 1940.

ASPECTS OF THE BIOLOGICAL FUNCTION OF PHOSPHATE IN ENZYMATIC SYNTHESES*

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IT is just forty years ago since the late Sir Arthur Harden, together with Dr. W. J. Young, published the significant results of their studies of the effect of inorganic orthophosphate on cell-free sugar fermentation. Harden and Young[1] showed that phosphate is an essential component of this system, and this not merely by acting as a catalyst. They succeeded in showing that phosphate participates as a reactant in the process, that is, it is being esterified to sugar. One mole phosphate is esterified per mole glucose converted into alcohol and carbon dioxide. The phosphoric ester which accumulates was already identified by Harden and Young as fructose-1-6-diphosphate, later called the 'Harden–Young ester'. The chemical events taking place were summarized by Harden and Young in the following equation:

2 glucose + 2 phosphate = 1 hexosediphosphate + 2 ethyl alcohol + 2 carbon dioxide.

Harden and Young's fundamental discoveries led to many other important studies such as Robison's and Embden's isolation of glucose monophosphates, Meyerhof and Lohmann's studies of glycolysis in muscle extracts and Lundsgaard's observations of the chemical events which accompany the alactacid muscle contraction.

These developments are familiar to investigators and students in this field. The purpose of the present survey is not to attempt a description of the historical development but rather to try to outline a picture of the present position in this field.

The problems to be discussed have been arranged in the following order:

(1) Generation of phosphate bond energy:

(*a*) from oxidation-reductions (formation of acyl-phosphates);

(*b*) from enol formation from dihydroxy structures (phosphopyruvate).

(2) Transfer of phosphate bond energy:

(*a*) reversible phosphate exchange (adenosine triphosphate-creatine-carboxyl);

(*b*) dephosphorylations (myosin adenosine triphosphatase);

(*c*) irreversible transphosphorylations (phosphorylation of hydroxy groups).

(3) Enzymatic exchange of aldehydephosphates with sugars and N-bases:

(*a*) polysaccharide formation (starch and glycogen from glucose-1-phosphate);

(*b*) dissaccharide formation (from glucose-1-phosphate);

(*c*) nucleoside formation (from ribose-1-phosphate and P-nucleic acid).

Such an arrangement is, of course, purely arbitrary, but it is hoped that it will facilitate the presentation of the problems to be discussed.

It is logical, for example, to start the discussion with a description of the characteristics of biological oxidation-reductions which, being reactions capable of releasing large amounts of energy, condition the occurrence of biological syntheses.

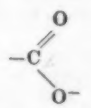
The first oxidation step in the breakdown of sugar is the oxidation of phosphotriose to phosphoglyceric acid, which is eventually converted into pyruvic acid. In fermentation, the latter is either reduced directly to lactic acid, which is the typical glycolysis, or reduced after decarboxylation, which is alcoholic fermentation. The conversion of phosphotriose to pyruvate involves two reactions which produce much energy. The first and most important of these steps is the oxidation of phosphoaldotriose to phosphoglyceric acid, the cozymase being the electron acceptor. The other reaction is the anhydride reaction by which the α-keto structure of pyruvic acid is formed from the dihydroxy structure of phosphoglyceric acid.

Phosphoglyceric acid, although poorer in energy than phosphotriose, is apparently endowed with an extra source of readily mobilized energy, namely, the possibility of converting the dihydroxy structure of this compound into the anhydride, pyruvic acid. Both the oxidation-reduction and the anhydride reaction are known to be coupled with the synthesis of the energy-rich phosphate bonds[2].

The oxidation of aldehydes to acids has hitherto been described according to Wieland's equation:

$$\text{aldehyde hydrate} \rightarrow \text{carboxylate} + 3H^+ + 2\varepsilon.$$

The release of free energy in this reaction is considerable, due to the formation of the highly stable carboxylate ion:



If one calculates the ΔF of the reaction aldotriose → glycerate, one finds that at *p*H 7 as much as 29,000 cal. are liberated per mole oxidized.

Calculation of ΔF of other aldehyde oxidations seems to give figures of the same order of magnitude, namely, between 28,000 and 30,000 cal. liberated per mole. This actually is a very large release of energy for a biological step-oxidation. The oxidation of lactate to pyruvate or of alcohol to aldehyde yields only some 8,000–9,000 cal. for example. It is natural to ask whether there is a pathway available to the living organism by which all the energy generated in aldehyde oxidations can be directed into something useful. At least two ways are known. One way, which is universally used, is through oxidation-reduction, that is, the energy of an oxidation is utilized to reduce something else; this type of energetic coupling occurs in glycolysis.

In glycolysis, aldotriose plays the function of a hydrogen and electron donor, and pyruvate (the α-keto group) as hydrogen and electron acceptor forming lactate. Since the oxidation of lactate to pyruvate at *p*H 7 yields 8,300 cal., the same amount of energy is required in order to reduce pyruvate to lactate.

The oxidation reduction in glycolysis is not a one-step but a two-step reaction. The electrons from the triose are first transferred to cozymase, a substance which was also described first by Harden and Young in 1906. The chemical constitution of cozymase was clarified by Warburg and Christian in 1936[3] and shown to be a diphospho pyridine nucleotide in which the nitrogen of the pyridine participates in the acceptance of the electrons donated from the aldehyde group of the triose.

* A lecture delivered at University College, London, on July 5, 1946.

It is well known that the triose which donates the electrons in this enzymatic oxidation is not a free triose but a triosephosphate. However, it is important to bear in mind that the phosphate group referred to is located in the 3-position of the triose and therefore far from the site of the oxidation. Nevertheless, we ought to keep the existence of this phosphate group in mind, since it will be important in a later step-reaction. The replacement of triose by triosephosphate, thermodynamically speaking, makes little difference. However, the replacement of pyruvate by diphospho pyridine nucleotide as an electron acceptor makes some difference. The system*

$$DPN^+ \rightleftarrows DPHN$$

has a lower redox potential than the system

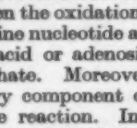
$$\text{pyruvate} \rightleftarrows \text{lactate}.$$

About 13,000 cal. are released when *DPHN* is oxidized to DPN^+ at *p*H 7. Consequently, the same amount of calories are required in reducing diphospho pyridine nucleotide to the reduced form. Thus, in the reaction

$$\text{phosphoglyceraldehyde} + DPN^+ \rightleftarrows \text{phosphoglycerate}^- + 2H^+ + DPHN,$$

13,000 cal. of the 29,000 cal. released by the aldehyde oxidation are being consumed for the reduction to the reduced cozymase. The reduced diphospho pyridine nucleotide formed can, of course, serve as a reducing system for numerous other compounds. The net free energy change at *p*H 7 of this oxidation-reduction is 16,000 cal.

A question of great significance is whether this still large amount of energy left over is available for synthetic processes. This question was attacked successfully by Needham and Green at Cambridge[4], and by Meyerhof and his group at Heidelberg[5]. These two groups have been able to show the existence of a coupling between the oxidation of triosephosphate by diphospho pyridine nucleotide and the phosphorylation of adenylic acid or adenosine diphosphate to adenosine triphosphate. Moreover, inorganic phosphate is a necessary component of this system and is consumed in the reaction. In order that phosphorylation shall proceed, oxidation is required; and the continuation of the latter reaction depends on the presence of phosphate acceptors. The two processes are therefore mutually dependent. The true nature of this interesting type of coupling has been clarified through some remarkable studies made by Warburg, Negelein and their co-workers[6,7]. These investigators succeeded in isolating a very peculiar ester, a carboxylphosphate, which is extremely labile and which is formed as the primary product in the enzymatic oxidation of phosphotriose. The discovery of this new type of phosphate ester made possible the first chemical formulation of a coupling between an oxidation and a biological synthesis based on enzyme experiments. According to this formulation, phosphate undergoes a sort of complex formation with aldehyde, and it is this complex which is oxidized, yielding a phosphorylated carboxyl group, a so-called acylphosphate.



* The Warburg – Haas terminology will be used, namely, oxidized cozymase is abbreviated to DPN^+ (diphospho pyridine nucleotide) to indicate the quaternary nitrogen, the reduced cozymase to *DPHN* (reduced diphospho pyridine nucleotide).

The reaction can be expressed by the following equation:

$$\text{phosphoglyceraldehyde} + \text{phosphate} + DPN^+ \rightleftarrows \text{phospho-glyceryl-phosphate} + DPHN.$$

Warburg and Christian found that this reaction was readily reversed. They determined the equilibrium constant at *p*H 7·4 and 37°; from these data ΔF can be calculated to be between 800 and 1,000 cal. This means that as much as 15,000 cal. have been bound as chemical (or potential) energy since, as will be remembered, the oxidation of phosphotriose to phosphoglycerate, without inorganic phosphate as a participant, had $-\Delta F$ of 16,000 cal. The aldehyde phosphate complex is generally assumed to require only a smaller amount of energy and to take place spontaneously. The 15,000 cal. bound are apparently accumulated in the acylphosphate. This is further supported by the fact that the acyl compound, that is, phospho glyceryl phosphate, is capable of phosphorylating adenosine diphosphate to adenosine triphosphate in the presence of a specific enzyme[8]. This reaction is an equilibrium which is far towards the side of adenosine triphosphate formation.

The bond energy of acylphosphate must be somewhat higher than the bond energy of a pyrophosphate linkage, which according to Lohmann's studies lies between 10,000 and 12,000 cal. per mole. Since the reaction between the acylphosphate and adenosine diphosphate can be reversed, it means that adenosine triphosphate is capable of phosphorylating a carboxylate group. From what was said previously, it will be understood that once the carboxyl group is phosphorylated it can readily undergo reduction to aldehyde through a labile aldehyde phosphate complex.

The old observation by Harden and Young that arsenate can replace phosphate as an activator in the cell-free fermentation and is active in minute amounts seems also to be explained by Warburg and Negelein's formulation. According to Warburg, arsenate is supposed to react with carbonyl groups like phosphate, and the only decisive difference is that the carboxyl arsenate formed by oxidation from the carbonyl complex undergoes a rapid spontaneous cleavage whereby inorganic arsenate is continuously regenerated. This spontaneous disintegration of the primary oxidation product would, of course, make the oxidation process irreversible, a fact which was actually observed by Warburg and Christian. Nevertheless, the coupling as such is supposed to exist also in the presence of arsenate and is only concealed by a secondary cleavage reaction. This example shows that the existence of numerous other important coupling reactions may be readily overlooked by reason of secondary disintegrations, non-enzymatic as well as enzymatic, of the primary reaction product formed.

Lipmann has discovered another acylphosphate which is being formed in biological oxidations, namely, acetyl phosphate[9]. This acyl compound is formed in the enzymatic oxidation of pyruvic acid:

$$\text{pyruvate} + \text{phosphate} \rightarrow \text{acetylphosphate} + 2H^+ + CO_2.$$

Acetylphosphate is also a powerful phosphate donor which is capable of phosphorylating adenosine diphosphate to the triphosphate. It has been found recently[10] that certain bacteria form butyryl phosphate in addition to acetylphosphate.

All the acylphosphates belong to the group having energy-rich phosphate bonds. This group includes

adenyl-pyrophosphate (*ATP*, *ADP*), phosphocreatine and phospho-enol-pyruvate. The group of energy-rich esters is characterized by having a potential energy which exceeds that of ordinary phosphate esters many times. The ordinary ester bonds have a potential energy between 1,000 and 3,000 cal.; the energy-rich phosphate bonds are endowed with potential energies exceeding 10,000 cal. per mole.

The appearance of a mesomeric configuration upon hydrolysis of the energy-rich phosphate esters might be an essential feature in the liberation of the large amount of energy. However, this aspect is a matter for a physical chemist to decide. It may be sufficient to state here that a large part of the oxidation energy released by oxidation of carbonyl groups in the presence of phosphate and the proper enzyme is stored as phosphate-bond energy. In the glycolysis in which pyruvate is the electron acceptor, an extraordinarily large proportion of the energy released in the oxido-reduction is accumulated as phosphate-bond energy.

I would like to mention another example in which one has strong reasons for suspecting an accumulation of energy in a phosphate bond. I am referring to Lipmann's investigations of the conversion of 2-phospho glyceric acid to free pyruvic acid[11,2]. The essential considerations in these theoretical studies were as follows: if free glyceric acid is converted into its anhydride, pyruvic acid, a great decrease in free energy is bound to occur. It can be calculated that about 12,500 cal. are released. Yet the conversion of 2-phosphoglycerate (an enzymatically formed isomer of 3-phosphoglycerate) into phospho-enol-pyruvate is accompanied by only a negligible amount of energy liberation. The 12,500 cal. of the anhydride reaction are stored and added to the ordinary phosphate ester-bond energy. The phospho-enol bond therefore releases altogether about 16,000 cal. upon hydrolysis. Correspondingly, phospho-enol-pyruvate is capable of phosphorylating adenosine diphosphate to adenosine triphosphate, and conversely adenosine triphosphate can phosphorylate pyruvate to phospho-enol-pyruvate. It has been found recently that the particular enzyme involved in this reaction is active only in the presence of potassium ions[12]. This potassium effect is apparently quite specific.

We have seen a few examples of how the breakdown of metabolites can bring about the synthesis of powerful phosphate bonds, especially adenosine triphosphate. The energy which is accumulated in adenosine triphosphate can be used either for specific purposes or transferred to other groups. It is a well-known fact that adenosine triphosphate can exchange reversibly its terminal phosphate group with amidines (creatine, arginine) just as it does with carboxyl groups. A peculiar enzymatic reaction is the phosphate dismutation which converts 2 moles of adenosine diphosphate into 1 mole of adenosine triphosphate and 1 mole of adenylic acid. This reaction is also readily reversed.

A great deal of interest has been directed towards the dephosphorylation of adenosine triphosphate in muscle, particularly after the observation by Engelhardt and Ljubimowa in 1939 that myosin, the contractile protein of muscle, contains large amounts of adenosine triphosphatase and that adenosine triphosphate itself exerts an effect on the mechanical properties of myosin. These observations were confirmed by Bailey and by Needham and co-workers. Recently, Szent-Györgyi and his co-workers[13] have made a number of interesting observations on the properties of myosin. Only a few of their main findings can be included in this account. Straub[14] found that the myosin hitherto described is a complex protein which can be separated into myosin proper, a protein which is crystallizable, and another protein called 'actin'. Dissociation of this complex, which is called 'acto-myosin', can be brought about by adenosine triphosphate and potassium ions in the proper concentrations. In 0·02 *M* potassium chloride and in the presence of magnesium ions, the addition of adenosine triphosphate causes a spectacular contraction of threads prepared from acto-myosin. The threads are also endowed with adenosine triphosphatase activity. If the potassium ion concentration is raised, the contracted thread relaxes again. We do not know how closely this experiment illustrates the normal contraction. It is of interest, however, to add that Buchthal and co-workers have found recently that pyrophosphate compounds cause contractions in muscle fibres and that adenosine triphosphate specifically brings about changes in the double refraction corresponding to restitution.

The role which the adenosine triphosphatase takes in muscular contraction is not clear as yet. Binkley[15] has suggested that there may be an interaction between phosphate groups and sulphydryl groups, yielding thioether linkages and free phosphate. This latter state should correspond to the contracted state. The above-mentioned dissociation between myosin and actin brought about by adenosine triphosphate might then be explained by a sort of phosphorolytic cleavage of thioether linkages, yielding adenosine diphosphate, a phospho protein and free SH groups. Such a type of reaction has been described by the same author in some *in vitro* experiments with liver extracts[16].

I do not think that it is an over-statement to say that a phosphorylation of the contractile protein of some sort or another is an alternative which deserves consideration in attempting to explain the transformation of chemical energy into mechanical. The relation of adenosine triphosphate and the triphosphatase activity to the mechanical function of myosin is undoubtedly a new and interesting approach in physiological chemistry.

The irreversible transphosphorylations by which adenosine triphosphate reacts with a number of hydroxy groups play a particularly important part in carbohydrate metabolism.

It may be added that a wide variety of hydroxy compounds are being phosphorylated enzymatically from adenosine triphosphate. Glycerol is phosphorylated to glycerophosphate in extracts of kidney cortex[17]. A bacterial enzyme is capable of catalysing the phosphorylation of one of the hydroxy groups in pyridoxal from adenosine triphosphate, yielding the phosphorylated pyridoxal compound, which is an active coenzyme[18].

The enzyme which catalyses the phosphorylation of monohexoses (glucose or fructose) to form hexose-monophosphates has been known for some time and called 'hexokinase', because it initiates carbohydrate metabolism, without regard to whether this means breakdown of hexoses or polysaccharide formation.

Cori and his co-workers[19] have recently made some interesting studies on muscle hexokinase. They found that this enzyme, if isolated from diabetic animals (alloxan-diabetic rats were used), is practically devoid of activity; but if a small amount of insulin was added the activity returned. The same phenomenon

was encountered if they used rat muscle from animals injected with Houssay's diabetogenic hormone from the anterior pituitary. They were also able to demonstrate the inhibitory effect of the anterior pituitary factor on hexokinase *in vitro*. Also in this case the inhibition was overcome by insulin. The muscle preparations slowly destroy the anterior pituitary factor.

If an unknown substance, belonging to the amorphous fraction of the adrenal cortical extract, is added, the action of anterior pituitary factor is enhanced and prolonged, presumably due to protection from destruction. As will be seen, most of these *in vitro* effects reproduce fairly well the *in vivo* observation made by Houssay, C. N. H. Long, F. G. Young and others. Cori emphasizes that insulin probably also has a direct effect on hexokinase, corresponding to the observation showing that hypophysectomized animals are highly sensitive to insulin.

Muscle hexokinase is apparently a rather complicated enzyme system also in other respects. Two more activators seem to be required, namely, reduced cozymase (*DPHN*) and guanine.

The ester formed by hexokinase and adenosine triphosphate is glucose-6-phosphate or Robison ester, which can be converted into fructose-6-phosphate (Neuberg ester), phosphorylated once more, and undergo cleavage and breakdown. The glucose-6-phosphate can also be converted into glucose-1-phosphate, the so-called Cori ester. The isolation of this 1-ester is of special significance, since it gave the clue to the understanding of the mechanism of the biological formation of polysaccharide. The discovery of the enzymatic formation of α-glucose-1-phosphate from glycogen and phosphate by Cori and Cori in 1936 [20] represents actually the first observation of a phosphorolytic reaction (that is, a reaction by which a linkage is broken by interaction of phosphate). The replacement of water by phosphate makes a great thermodynamical difference also in this case. The hydrolytic splitting of polysaccharides is practically irreversible, whereas the phosphorolytic splitting of this group of compounds is readily reversed.

It has been found that in order to start an enzymatic synthesis of polysaccharides the presence of minute amounts of glycogen is required prior to the reaction. Cori, Cori and Green[21] have found that the synthesis of polysaccharide from glucose-1-phosphate can actually be described as a lengthening of the existing maltosidic chains. The crystalline muscle phosphorylase builds up an amylose-like polysaccharide with long chains and no extra branches. The best priming substance for this enzyme is the highly branched glycogen, which contains a comparatively large number of terminal glucose molecules. The larger the amounts of glycogen added the faster is the reaction. This reaction can be formulated as follows:

glucose-1-phosphate + terminal glucose ⇄ terminal maltosidic linkage + phosphate.

It can be seen that the phosphate of the aldehyde group is replaced by a terminal glucose through a 1-4 linkage. Doudoroff[22] has found that certain bacteria synthesize sucrose in an analogous manner, that is, according to the equation:

glucose-1-phosphate + fructose ⇄ glucose-1-fructose + phosphate.

On the other hand, the 1-6 polysaccharide dextran

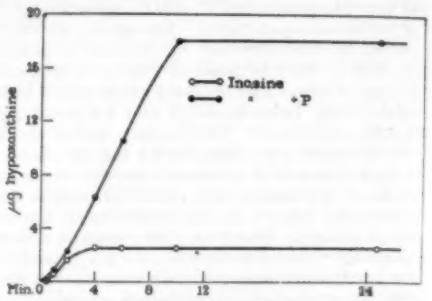


Fig. 1. Effect of inorganic phosphate on the enzymatic liberation of hypoxanthine from hypoxanthine-riboside (inosine). Enzyme used: nucleoside phosphorylase fractionated from rat liver. The amount of phosphate (P) added was 25 μgm. Ordinate: μgm. hypoxanthine liberated. Abscissa: incubation time in minutes

is synthesized according to a somewhat different although analogous scheme, described by the equation:

glucose-1-fructose + terminal glucose (⇄) 1-6-glucosidic linkage + fructose[23].

In this case fructose has the same role as phosphate. There is also a lævulan-synthesizing enzyme in which fructose is incorporated, and glucose takes the role of a phosphate group in replacing water and thus making the reaction reversible.

The Cori equation for glycoside synthesis apparently holds the key to a large number of important syntheses. The phosphorolytic reactions may also play a part in the biological synthesis of purine ribosides and related nucleosides. We have found recently[24] that nucleosidase, which liberates purines from nucleosides, was inactive in the absence of phosphate and could be re-activated by addition of comparatively small amounts of phosphates (see Fig. 1). This phenomenon was actually a confirmation of an earlier observation made by W. Klein in Freiburg[25]. Fig. 1 shows the great resemblance this phosphate effect bears to the Harden–Young effect and to the observations made by Cori and Doudoroff. It was natural, therefore, to assume that in this case also phosphate participated in the reaction and that a phosphate ester was formed. The search for this ester was somewhat hampered by the great lability of the new ester towards acids. The application of Lowry and Lopez's phosphate method[26] which operates at weakly acid reactions (around *p*H 4) greatly facilitated the further clarification of the enzymatic nucleoside fission. Thus one mole of phosphate was taken up in a highly labile bond for each mole of purine liberated. This relationship was found to be valid for hypoxanthine nucleosides and guanine nucleosides.

The new labile ester was isolated and analysed. It is non-reducing and contains one ribose per mole labile phosphorus. It is more acid-labile than phosphocreatine; fifty per cent of the new ester is broken down in 2·5 min. in Fiske and Subbarow's reagent at room temperature[26]. Upon acid hydrolysis, the ester becomes reducing, showing one aldose group per mole phosphate and ribose. We therefore have felt justified in calling it 'ribose-1-phosphate'. The more detailed chemical properties of this ester, particularly whether it is an α- or a β-ester, will have to be clarified by organic chemists. There is every reason to think that these problems will be solved in

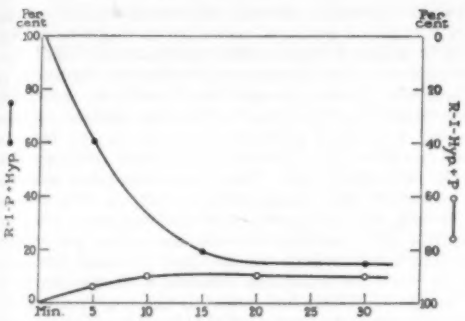


Fig. 2. EQUILIBRIUM BETWEEN A PURINE-RIBOSIDE (*R—I—Hyp*) AND THE PHOSPHO-RIBOSIDE (RIBOSE-1-PHOSPHATE, *R—I—P*). ENZYME: NUCLEOSIDE PHOSPHORYLASE FROM RAT LIVER. SUBSTRATE: EQUIMOLAR AMOUNTS OF *R—I—P* AND *Hyp* (LEFT ORDINATE) OR OF *R—I—Hyp* AND *P* (RIGHT ORDINATE). ORDINATES: PERCENTAGE OF INITIAL CONCENTRATIONS OF COMPONENTS REACTING. ABSCISSA: INCUBATION TIME IN MINUTES

the near future, by an application of the elegant technique developed recently in this field by Prof. A. R. Todd and Dr. R. J. Lythgoe.

If ribose-1-phosphate is incubated with hypoxanthine or guanine in the presence of a small amount of purified liver nucleosidase, an extensive synthesis of purine riboside takes place. The effect is particularly marked with hypoxanthine. Almost 80 per cent of the hypoxanthine is incorporated as a nucleoside. The equation for this type of reaction could be formulated as follows:

ribose-1-phosphate + purine $\rightleftharpoons$ ribose-1-purine + phosphate.

The equilibrium can be studied from both sides as illustrated in Fig. 2. The reaction is actually an enzymatic exchange between phosphate and purine. A very nearly related type of reaction has recently been described by Colowick and Price[27]. They found an enzyme in skeletal muscle which catalyses an exchange between guanine in ribonucleic acid and inorganic phosphate. The ribose-1-phosphate in the nucleic acid is even more acid-labile than that obtained from free nucleosides. Nevertheless, it has been possible to isolate small quantities of this 'deguanized' ribonucleic acid, which might also be called 'phospho-nucleic acid'. The demonstration of a guanine-phosphate cycle in nucleic acid may be important for an understanding of the biological function of nucleic acids.

I have occupied the major part of my space in dealing with *in vitro* studies and especially enzyme studies. The reason for this is mainly because these studies have taught us the intricate mechanism of the coupled oxidations and syntheses in which phosphate seems to have such an essential role. Before I finish this account, however, it seems natural to mention the ever-increasing number of studies of phosphate metabolism in various tissues *in vivo* using isotopic phosphate[28]. By means of this technique, it has been found that some of the most important phosphoric esters in muscle and liver are being rejuvenated with great rapidity[29,30]. Thus, after less than half an hour, more than fifty per cent of the phosphorus in adenosine triphosphate has been rejuvenated in the resting muscle, and only about five minutes are required to effect the same degree of rejuvenation of the adenylpyrophosphate present in liver[30]. These and many other observations bear witness to the occurrence of a very rapid uptake, transfer and liberation of phosphate in the living cells. The application of the same technique in the exploration of nucleic acid metabolism has been initiated recently by a number of investigators. These studies will undoubtedly produce many more interesting results, and perhaps be able to throw some light on the relationship between nucleic acid metabolism and cellular growth.

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By F. J. DOWNS

Deputy Director, British Families Education Service

HISTORICALLY, the British Army has always maintained a goodly proportion of its strength overseas on service away from Britain. In peace (and within living memory during war, too) it has been the right of the regular soldier on certain conditions to have his wife and family with him on foreign service. For more than a hundred years, therefore, it has largely fallen to the Army to provide schools for British children overseas.

In Germany to-day elements of the three Services and the civilian Control Commission for Germany are serving in what is officially described by the Services as a 'home station'. It is therefore appropriate that arrangements for the British children who have joined their parents in Germany should follow the pattern of educational arrangements in the United Kingdom, and for this purpose a civilian organisation, the British Families Education Service, was established.

The British Families Education Service has taken as its mandate the implementation of the provisions of the Education Act, 1944, for all British children in Germany in so far as conditions here permit. Departmentally, its organisation is very similar to that of a local education authority in Great Britain. The B.F.E.S. policy-forming committee is regularly composed of high ranking officers representing the users of the school service (that is, the three Services and C.C.G.) and the director of the B.F.E.S., with occasional full representation by the Ministry of Education. This local "Education Committee" in Germany has become known as "The Board of Education, B.A.O.R.", and meets regularly each month to determine how best to interpret the Education Act, 1944, for British children in Germany to-day.

The implementation of agreed policy in the light of local conditions is co-ordinated by the British Families Education Service, at its headquarters offices at Herford, and effected by the regional education officers who are stationed with their staffs at each of the Control Commission Regions in the British Zone and in the British Sector, Berlin. These regional education officers, therefore, correspond to divisional education officers in Great Britain. All British teachers working with B.F.E.S. in Germany are from schools in Britain. Many have been seconded by their local education authorities at home for periods of from one to three years, and it is a widely held view that the breadth of experience the teachers will gain from the working conditions in Germany will at least partly reward the local education authorities at home for generously agreeing to secondment at a time when they are themselves in need of all their teachers. In addition to the British teachers, some Germans are employed part-time as nursery helpers and for some specialist subjects for which there are not sufficient British staff.

The H.Q. offices of the B.F.E.S. were established in Herford on September 24, 1946. Regional offices were opened and the first British teacher arrived in Germany during November 1946. Now after about nine months there are 220 teachers at work with about four thousand British children in about seventy different places. It is thus too soon to draw any but the most tentative conclusions from this first British local education authority overseas; but one or two points are worth noting.

The majority of the children arriving here from the United Kingdom are in the lower age group. Plans for the next stage of development anticipate a child population of some 10,000, which will break down as follows: 2,000 under 3 years of age; 2,000 between 3 and 5 years of age; 4,800 between 5 and 11 years of age; 1,200, 11 years of age and over.

Thus, numerically, the problem is about the same as for a small county at home; but in Germany to-day there are additional factors which make for complication in the organisation of education for the British children. Chief of these complications is that the children are unevenly scattered throughout 20,000 square miles of territory, with outliers in the Low Countries and Berlin. In some areas there are only three or four British children, in others three or four hundred.

It will therefore be apparent that if B.F.E.S. has had to establish school groups in about seventy different places the broad pattern will be for most of the British child concentrations to be between 10 and 150 strong, with a few larger concentrations of between 150–400. In such circumstances co-education becomes a practical necessity in order to economize in teachers, equipment, materials and buildings. It will be equally apparent that whereas the nursery, infant and junior groups are usually in teachable concentrations, the effect of uneven scatter on the smaller secondary population is, locally, to leave a large number of embarrassingly small 'senior tops' to the primary groups. This very inadequate solution is naturally only acceptable as an interim means of giving education on quasi-Dalton plan lines to children of secondary school age who have been brought to Germany in advance of arrangements being made for adequate secondary education.

So the B.F.E.S. has come to the conclusion that the only way that most of the British children over 11 years of age can receive satisfactory secondary education suitable for their age, ability and aptitude is by attending boarding schools. Accordingly, on July 1, 1947, the first publicly maintained co-educational secondary boarding school was opened at Wilhelmshaven in premises recently vacated by the Royal Navy.

The B.F.E.S. Prince Rupert (Secondary) Boarding School, Wilhelmshaven, will cater for 250 boys and girls. It is calculated that at least two further boarding schools of similar size (or rather larger) will be needed to provide education for those children of secondary age who can only be offered appropriate education in boarding schools. The demand undoubtedly exists among parents, more than four hundred having applied within a week of the first announcement about Wilhelmshaven; and further secondary schools will be established immediately B.F.E.S. is offered suitable buildings. It now seems likely that it may be possible to open a second large boarding school by Christmas. Apart from secondary education in boarding schools it has been found possible to establish a day secondary element of reasonable size in Hamburg, and necessary, because of its isolation, to have a similar secondary element in Berlin. Outside Wilhelmshaven, Hamburg and Berlin, B.F.E.S. teachers are only at the moment able to make *ad hoc* time-marking arrangements for children of secondary school age, and so the position will remain until further buildings are made available for secondary boarding schools.

Scattering has not complicated the establishment of primary school groups to anything like the extent that it has conditioned the basis of secondary provision. Primary groups are therefore being established to a more familiar pattern, though the school buildings on the whole are somewhat unexpected, and bear more resemblance to the conventional idea of 'private academies for young gentlefolk' charging expensive fees than to State schools charging nothing.

Scatter in most places has necessitated that British children attending day schools are collected in buses. Although distances are carefully watched, and the very young children are not allowed to travel, it is often inevitable at this stage that some children travel farther to school each day than is normally desirable. So, for economy of time and effort alone a school meals service would have been desirable in Germany to avoid a double midday journey, even were there not even stronger social training reasons for its institution. The B.F.E.S. school meals scheme for all school groups officially began early in May 1947 on a basis of container meals cooked in the nearest mess and transported to the school for the children to take their midday meal there. Later,

as kitchens are prepared and equipped each school group will have its own cooking arrangements, as some already have.

B.F.E.S. has also instituted a school library service of several thousand volumes circulated in a hundred specially designed travelling showcases, which are used as portable lending libraries on arrival at the schools.

Now that B.F.E.S. is settling in, we are all very conscious that there is a long way to go and many problems to solve before the Education Act, 1944, is a complete reality for every British child in Germany. Books are still lamentably short, and starting as we are from scratch there are no past stocks on which to draw. There is certainly a lower limit below which book supplies should never fall; but anyone who has seen the improvisations and class teaching of B.F.E.S. teachers who can only, at the moment, be supplied with a small percentage of the books they want, may reach the conclusion that schools and school teachers have tended to put this lower limit too high. Like books, furniture and equipment is neither fully in position nor, in every case, to the requested specification of B.F.E.S.: each month, however, sees improvement.

School organisation is also seriously complicated by the movement of families, and here the Services are the chief offenders. One boy of nine, for example, had been in six different schools at various Army stations, while one B.F.E.S. school lost overnight twenty children from one regiment to receive in exchange twenty-five children from another. At the same time continual movement on any scale may well necessitate a degree of standardization of curriculum and text-books in order that the movement of children from one school to another can be accomplished as smoothly as possible. Similar standardization was forced upon Army schools, which have had continually to cope with the same problem.

It is far too early to estimate the psychological effect of residence in Germany on the British children. It is unhappily true that values are awry here to-day, and the British child may well get a sense of power which he is ill-adapted to assume. His few sweets, for example, have appreciable 'black market' purchasing power; the eagerness to do his bidding on the part of servants at home and in the families' clubs may breed in him an unnecessary arrogance; he may find, expediency being what it is, that a German boy may be cuffed by him without hitting back. Alternatively, he may find his sympathies overplayed and his outlook distorted by the many sights that can and have done both to adults working in Germany to-day.

Nevertheless, when all possible difficulties are appreciated a great deal remains on the credit side. The British schools in Germany can provide the German people with a very positive demonstration of British education in practice in their midst; and the behaviour of our children will be watched equally with the curriculum, as the behaviour of our occupation forces is at least as important as our formal laws and ordinances. For the British children themselves there is a profound potential for good in their attending a British school in Germany to-day. They will probably emerge bi-lingual, they will have wide opportunities for exploration, and they should emerge with a wider and more elastic attitude to their work, for their real joy in being at school is very apparent. Fundamentally, the chief determinant of whether bringing the children to Germany was a good or bad thing will be the quality of the British education provided here. This, in its turn, is a reflexion not merely of the printed word of the Education Act, but also of the skill and enthusiasm of the teachers in putting it into effect in the schools.

In its teachers, B.F.E.S. has been more than fortunate, and we all hope and believe that they themselves will benefit from the experience of a stay in Germany at least in proportion to the willing and excellent service they are giving the British children in Germany to-day.

NEWS and VIEWS

Hydraulic Research Organization: Sir Claude Inglis, C.I.E.

With the appointment of Sir Claude Inglis as director of the new Hydraulic Research Organisation, the proposal to form a National Hydraulics Laboratory in Great Britain moves one more step towards realization. Sir Claude's work in India, where for many years he has been the leading exponent of the systematic use of models in the design of large civil engineering works, is known throughout the hydraulic laboratories of the world. He became director of the Central Irrigation and Hydrodynamic Research Station (now the Indian Waterways Experiment Station), Poona, in 1937, when it was taken over by the Government of India, and there, and in his previous capacity as superintendent engineer of the Research Division of the Bombay Irrigation Service, he has been responsible for the solution of a wide range of problems in river control: for example, the safeguarding, in 1934, of the Harding Bridge on the Ganges, where previously repairs alone had cost nearly a million pounds in two years, and the determination of the origin and remedy for the flooding of the Indus in 1942. Earlier, as assistant engineer or as executive engineer, Sir Claude was in charge of the construction of many works, including the building and remodelling of several canal systems in the Deccan. Such constructional experience should ensure that practical difficulties will be given full attention in the designs emanating from his Laboratory.

Perhaps the most important application of hydraulic work lies in the botanical and agricultural fields, and Sir Claude has had long experience in this, for in 1913 as executive engineer of the Poona Irrigation District he was reporting upon salt-saturation of soils arising from irrigation and evaporation; also at about that time he was responsible for introducing new and successful methods in connexion with land drainage and reclamation in the Deccan. His publications on hydraulics include such subjects as river meander, river training, scale effects and the use of distorted models, and he has been responsible for technical reports on very many irrigation, river and coastal works, many of which have been printed in the Annual Reports (Technical) of the Indian Waterways Experiment Station.

Metropolitan-Vickers Electrical Co., Ltd.: Dr. C. Dannatt, O.B.E.

DR. C. DANNATT has been appointed chief electrical engineer of the Metropolitan-Vickers Electrical Co., Ltd., in succession to Mr. G. A. Juhlin, who has resigned, though retaining his connexion with the Company. Dr. Dannatt received his technical education under Prof. W. M. Thornton at Armstrong College, Newcastle, from which he graduated in electrical engineering in 1921. His studies were interrupted by the First World War. Dr. Dannatt went to Metropolitan-Vickers as a college apprentice in 1921 and afterwards joined the electrical and magnetic section of the Research Department, taking charge of the section in 1924. His activities have been mainly concerned with engineering investigations, and he is a recognized authority on electrical measurements especially in relation to magnetism and the behaviour of dielectrics. He is the principal author of a volume on "Electrical Power Transmission and Interconnection". In 1936 he was awarded the degree of D.Sc. by the University of Durham. Dr. Dannatt was appointed to the chair of electrical engineering in the University of Birmingham in August 1940; but at the request of the Admiralty he continued part-time activities with the Metropolitan-Vickers Co.; in the New Year Honours List of 1943 he was awarded the O.B.E. for contributions to naval gunnery. In 1944 he returned to Metropolitan-Vickers as assistant to the chief electrical engineer, and in the following year he was appointed deputy chief electrical engineer.

Mining and Metallurgy at Adelaide: Prof. E. C. R. Spooner

THE Council of the University of Adelaide has appointed Dr. Edgar Clynton Ross Spooner to be professor of mining and metallurgy and director of the Bonython Laboratories at the South Australian School of Mines and Industries, in succession to Prof. H. W. Gartrell, who died two years ago. Prof. Spooner, who is thirty-nine, was born and received his undergraduate education in Tasmania, and was Tasmanian Rhodes Scholar in 1931. At Oxford he carried out research into electrode potential phenomena, for which he was awarded the degree of doctor of philosophy in 1936, and in 1946 the University of Tasmania conferred on him the degree of doctor of science for further research work in that field. On leaving Oxford, Prof. Spooner was for two years technical assistant to the works director of the National Smelting Company, Avonmouth, and then for seven years technical superintendent and works manager, and later assistant general manager, to the Magnesium Metal Corporation, Ltd., Swansea. Since December 1944 he has been technical adviser to S. G. Warburg and Company and director of research and development to Sutcliffe, Speakman and Company. In 1946 he was a member of the British Industrial Mission which investigated and reported on the active carbon industry of Germany.

Defence Scientific Advisory Committee, Australia

IT was announced in *Nature* of June 28, p. 869, that Mr. A. P. Rowe had been appointed to take charge of a scientific advisory committee for defence in Australia. The United Kingdom Government has agreed to loan Mr. Rowe's services for a period of one year to the Australian Government for the purpose. Mr. Rowe will carry out the functions of defence scientific adviser in Australia and will establish a Defence Scientific Advisory Committee of which he will be chairman. The Committee will be constituted as follows: Defence Scientific Adviser, a representative of the Council for Scientific and Industrial Research, and one representative each of the following subjects—physics, chemistry, engineering and medicine; specialist Service and munitions representatives and scientific workers will be co-opted as required. The functions of this Committee will be to maintain a general survey of the scientific field and bring to the notice of the Defence Committee and the Chiefs of Staff Committee or through the Council of Defence to the Government, scientific developments having either direct or indirect bearing upon national defence.

British Hat and Allied Feltmakers Research Association: Dr. Thomas Barr

DR. THOMAS BARR has been appointed director of research to the British Hat and Allied Feltmakers Research Association. This newly formed Research Association will carry out investigations on problems provided by members of the felt-hat industry. Initially, the work of the Association will be carried out in accommodation provided by the Textile Industries Department of the University of Leeds. The location of the new research group at Leeds should prove an attraction and stimulus, since for the past quarter of a century Leeds has been one of the most active centres of both fundamental and applied research on animal fibres. Dr. Barr is at present in charge of a research section in the I.C.I. Dyestuffs Division, carrying out fundamental research work on textile processes involving the study of cellulose, natural and regenerated, the modification of wool and physiochemical studies of colloidal electrolytes such as synthetic detergents, etc.

'Sponsored' Research for Industry

IN his address when opening the Fulmer Research Institute at Stoke Poges on July 2 (see p. 165), Sir Stafford Cripps said that the new Institute, which is constituted broadly on lines similar to the Mellon Institute in the United States, may well be the prototype of a kind of research organisation which could largely fill the gap between scientific research and its application in production processes, particularly for the smaller firms. There are, he said, three essential principles in any research institute which seeks to perform this general function for industry: its staff and equipment must be first class; the results of research sponsored by an individual firm must be retained by that firm, either as patents or as general technique and knowledge; and thirdly, the Institute should not be profit-making. Research and profit-making, he believes, do not mix well together, and although research should be carried out with reasonable economy, and elaborate equipment may not be necessary, it must be allowed ample time and a wide range of experimental failure. All these principles have been adopted in setting up the Fulmer Research Institute, and it has also been arranged for members of the staff of the sponsor firms to go and work in the Institute so as to be in a position to translate the results of the research readily into terms of factory processes. Sir Stafford Cripps also commended the Institute for the economy in scientific effort and said that the Government heartily welcomes this initiative as filling the gap which will be left even when joint research organisations have been set up

as contemplated under the new Industrial Development and Organisation Act. In the first instance, the Fulmer Research Institute will concentrate upon metallurgical research, though other fields will be entered as the work develops.

University Teaching in Agriculture and Horticulture

In reply to a question asked in the House of Commons, the Minister of Agriculture, Mr. T. Williams, stated that the universities of Britain are sympathetic in principle with the proposals of the Committee on Higher Agricultural Education for raising the standard of degree courses in agriculture and horticulture, and have carefully noted the detailed suggestions in the report relating to the form and content of the courses. The Committee's comprehensive plan for the development and allocation of graduate courses is generally acceptable to the universities, some of which are hoping to introduce courses on the lines suggested this year or next. The main administrative recommendation of the Committee was that responsibility for grants in aid of higher agricultural and horticultural education at universities should be transferred from the Ministry of Agriculture to the University Grants Committee as from the beginning of the academic year 1947–48, on the understanding that the University Grants Committee would set up a specialist sub-committee to provide it with the necessary technical advice. Mr. Williams said that after consultation with the universities and with the Treasury he has accepted this recommendation, though he will naturally retain a close interest in the development of university teaching in agriculture and horticulture.

The constitution of the Agricultural Sub-Committee appointed by the University Grants Committee is as follows: Dr. A. E. Trueman (*chairman*), J. M. Caie, Prof. N. M. Comber, Sir Frank Engledow, Sir John Fryer, Sir Bryner Jones, Dr. Thomas Loveday, Prof. H. A. D. Neville, Dr. W. G. Ogg, Frank Rayns, Prof. E. K. Rideal, Sir Edward Salisbury and Dr. Norman Wright.

Foot-and-Mouth Disease Research Committee

The Minister of Agriculture and Fisheries has reconstituted the Foot-and-Mouth Disease Research Committee with the following membership: Dr. A. N. Drury (*chairman*), director of the Lister Institute of Preventive Medicine; Dr. C. H. Andrewes, of the scientific staff of the National Institute for Medical Research and a fellow of the Royal Society; Prof. S. P. Bedson, Goldsmiths' professor of bacteriology in the University of London at the London Hospital Medical College; Sir Daniel Cabot, chief veterinary officer of the Ministry of Agriculture and Fisheries; Mr. T. Dalling, director of the Ministry of Agriculture and Fisheries Veterinary Laboratory at Weybridge; Dr. R. E. Glover, director of the Laboratory Animals Bureau, Medical Research Council; Dr. Russell Greig, director of the Moredun Institute of the Animal Diseases Research Association, Edinburgh. Dr. I. A. Galloway, director of the Foot-and-Mouth Disease Research Station, and Mr. F. A. Eveleigh, of the Ministry of Agriculture, have been appointed secretaries to the Committee. The terms of reference of the Committee remain as follows: "To initiate, direct, and conduct investigations into foot-and-mouth disease either in this country or elsewhere, with a view to discovering means of rendering the invasions of the disease less harmful to agriculture".

Historical Library, Yale University School of Medicine

The sixth annual report of the Historical Library, Yale University School of Medicine, to which are appended the Chief Cataloguer's report and a list of the Monograph series issued by the Library, covering the year ended June 30, 1946, summarizes the principal points in the Library's plan for the next five years. This plan is based on the conviction that with the growing importance of science in the curricula of universities as well as in national life and international thought, greater stress must be placed upon the history of science and upon the humanistic values attached thereto. One of the primary aims of the new plan is to make the Historical Library the University's centre for historical studies in medicine and the allied sciences. For this purpose it is planned to augment Yale's holdings in medicine and allied sciences and, in co-operation with the University Library, to make them freely available throughout the University. The report directs special attention to some of the present holdings of the Library, such as those in the history of astronomy, geology, and early physics; and in particular the special collections in chemistry which, in addition to the works of Robert Boyle, John Mayow, Luigi Galvani, Alessandro Volta, Joseph Priestley and Antoine-Laurent Lavoisier, include all the writings of Sir Humphry Davy. The Library also has extensive Linnean holdings, and has concentrated heavily on the history of scientific societies in the seventeenth century. The new plan contemplates the creation of a chair of the history of medicine and science, and the extension of the Library's publications, both the Monograph series and the series of papers on bibliography and the history of medicine, as well as frequent exhibits of books, manuscripts and museum holdings.

During the year 1945–46, the Library staff formulated plans for a new periodical, the *Journal of the History of Medicine*. Distinguished visitors were received from many parts of the world, and space was assigned for editorial offices of *Cancer Research* and of the history of the U.S.A. Typhus Commission. The Library was actively associated during the year with the compilation of the Bibliography of Scientific, Medical and Technical Books, issued by a committee of the National Research Council, with an amplified translation of Dr. A. Castiglioni's "Adventures of the Mind", and with Mrs. M. L. Duran-Reynal's monograph on the history of quinine.

Demonstration Models of Physical Processes

Two interesting models, originally designed for exhibition in the Science Museum, London, have been described by Dr. F. A. Ward (*Proc. Phys. Soc.*, Jan. 1947). The first illustrates, by an optical analogy, the principle of the Bragg X-ray spectrometer, namely, that a monochromatic beam of X-rays will be reflected by a single crystal only when the crystal is set at a particular angle to the incident beam such that reflexions from successive sheets rich in atoms are in phase and so give an interference maximum. The incident beam is represented by a sheet of corrugated iron, and the crystal to be analysed by four glass plates mounted on a wooden rack. The observer looks into the glass plates, and rotates them until the virtual images of the crests of the corrugations appear to coalesce. The second model is a mechanical one illustrating the uranium chain

reaction which has been utilized for the release of atomic energy. It consists of thirty units, each representing the nucleus of an atom of uranium 235 or plutonium. A unit consists of two portions held together by a catch which, when released, allows the two portions to fly apart, while at the same time projecting upwards three table-tennis balls representing neutrons. A single 'neutron' dropped on the catch of one of the units disintegrates this unit, and the three ejected 'neutrons' impinging on neighbouring units cause them to disintegrate, thus initiating the chain reaction. Both these models have been demonstrated at the Physical Society's science meetings, at the Society's Exhibition of Scientific Instruments and Apparatus, and also at the recent Royal Society conversazione, where they have aroused considerable interest.

Beit Memorial Fellowships for Medical Research

THE Trustees of the Beit Memorial Fellowships for Medical Research have received with regret the resignations of Lord Rayleigh and Lord Macmillan of Aberfeldy; Sir Henry Dale and Lord du Parcq have been appointed to succeed them. The following elections have been made: *Fourth Year Fellowship* (£700 a year): F. Sanger, to study the structure of proteins with special reference to insulin (at the Department of Biochemistry, University of Cambridge). *Junior Fellowships* (normal value £600 a year): J. W. Lyttleton, to study the purification and subsequent physico-chemical characterization of proteins involved in the coagulation of blood (at the Lister Institute of Preventive Medicine, London); A. J. Marshall, to study the humoral and nervous control of the decidual reaction of the mammalian uterus (at the Department of Zoology and Comparative Anatomy, Oxford); L. Silberman, to study the community costs of tuberculosis in terms of public assistance and industrial outlay to patients and dependants, man-day wastage and social service provisions with special reference to the problem of reinstatement and revocation (at the University of Birmingham); Dr. G. Weber, to investigate the reactions and behaviour of physiologically important proteins (at the Sir William Dunn School of Biochemistry, University of Cambridge).

Institution of Electrical Engineers: Awards

THE Council of the Institution of Electrical Engineers has made the following awards of premiums for papers read or accepted for publication during the session 1946–47. Group A: *Institution Premium:* Dr. H. G. Booker; *Kelvin Premium:* Dr. H. A. H. Boot and Prof. J. T. Randall; *John Hopkinson Premium:* H. A. Thomas. Group B: *Non-Section Premiums:* J. R. Mortlock and C. M. Dobson (Ayrton Premium), J. Hacking and J. D. Peattie (Llewellyn B. Atkinson Premium), C. H. Sparks (Extra Premium); *Installations Section Premium:* V. J. Francis and W. R. Stevens (Crompton Premium), F. Widnall and R. Newbound (Swan Premium), C. F. Freeman and H. V. Mather (Extra Premium); *Measurements Section Premiums:* W. Casson and Dr. F. H. Last (Silvanus Thompson Premium), Dr. F. M. Bruce (Mather Premium), Dr. A. L. Whiteley (Extra Premium), G. H. Farrington (Extra Premium), Dr. A. M. H. Arnold (Extra Premium); *Radio Section Premiums:* Dr. D. C. Espley, E. C. Cherry and M. M. Levy (Duddell Premium), C. Crampton (Extra Premium), W. Ross (Ambrose Fleming Premium), Dr. D. Gabor (Extra Premium), J. Bell, M. R. Gavin, Dr. E. G. James and G. W. Warren (Extra Premium), C. J. Banwell (Extra Premium), Dr. J. H. Fremlin, A. W. Gent, D. P. R. Petrie, P. T. Wallis and Dr. S. G. Tomlin (Extra Premium), D. Cooke, Z. Jelonek, A. J. Oxford and E. Fitch (Extra Premium); *Transmission Section Premiums:* G. T. Garwood (Sebastian de Ferranti Premium), T. R. P. Harrison (John Snell Premium), R. C. Cuffe (Extra Premium). Group C: *Fahie Premium:* E. P. G. Wright; *Paris Exhibition* (1881) *Premium:* W. Fordham Cooper; *Webber Premium:* W. E. C. Lampert; *Overseas Premium* (for senior members): T. S. Skillman.

Announcements

THE First Class of the Order of Agriculture has been conferred on Dr. W. Lawrence Balls, recently chief cotton technologist of the Egyptian Ministry of Agriculture, by the King of Egypt on the occasion of his resignation from that country's service.

PROF. ARTHUR HOLMES, regius professor of geology in the University of Edinburgh, has been elected a member of the Section of Natural Sciences of the Royal Netherlands Academy of Sciences.

PROF. GUSTAVE RIBAUD, professor of pyrometry in the University of Paris, has been elected a member of the Section of General Physics of the Paris Academy of Sciences.

IN connexion with the recent International Physiological Congress, the University of Oxford conferred the honorary degree of D.Sc. on the following: Prof. S. A. S. Krogh, emeritus professor of zoophysiology in the University of Copenhagen; Prof. A. Szent-Györgyi, professor of biochemistry in the University of Szeged; Dr. H. S. Gasser, director of the Rockefeller Institute for Medical Research; Prof. B. A. Houssay, recently professor of physiology in the University of Buenos Aires; and Dr. C. H. Best, professor and head of the Department of Physiology, University of Toronto.

Profs. A. C. Chibnall, G. R. Cameron and D. Brunt have been appointed members of the Agricultural Research Council. Sir Frank Engledow and Prof. James Gray retired from membership of the Council on July 1 on the expiry of their terms of office.

DR. C. L. F. HUNTER has been appointed by Pal Chemicals, Ltd., as director of the Bray Research Station, which is carrying out research into agricultural problems.

DR. FRANS VERDOORN, managing editor of *Chronica Botanica*, has been appointed an honorary staff member of the Government Botanic Gardens, Buitenzorg, Java, on the occasion of the hundred and thirtieth anniversary of the Garden on May 18, in recognition of his work, during the war years, on behalf of the scientific institutions of the Netherlands Indies.

THE following appointments in the Colonial Service have been announced: R. B. Blyth, to be superintendent of agriculture, Nigeria; J. L. Congdon, to be agricultural officer, Aden; H. W. Dougall, to be agricultural chemist, Sierra Leone/Gambia; J. M. Waterston (plant pathologist, Bermuda), to be senior botanist, Nigeria; L. R. Langridge (senior surveyor, Nigeria), to be divisional surveyor, Nigeria; E. D. Stanfeld (director of surveys, Jamaica), to be superintendent, Crown Lands and Surveys, Hong Kong.

LETTERS TO THE EDITORS

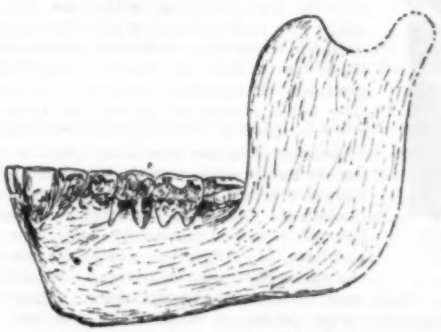
The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Jaw of the Male Sterkfontein Ape-man

On June 24, we blasted out at Sterkfontein, at a spot only about 8 ft. away from where we discovered the old female skull of *Plesianthropus*, the almost perfect lower jaw of a large male. The left mandible is complete except for the loss of the condyle and a little part of the margin of the angle. The whole symphysial region appears to be complete, while the right ramus is much broken and crushed. All the teeth of the left side are present, though worn.

The horizontal ramus is considerably larger than that of man but essentially similar. The ascending ramus is higher than in man, but otherwise not unlike that of the human jaw.

The front of the jaw is remarkably interesting. It does not slope rapidly backwards as in the living anthropoids but more downwards than backwards, giving an appearance not unlike that of the Heidelberg jaw. The front of the Sterkfontein jaw is narrower owing to the incisors being smaller. The symphysis, so far as can yet be seen, seems to agree fairly well with that of the Heidelberg jaw, and there appears to be no simian shelf.



TRUE SIDE VIEW OF MANDIBLE OF MALE *Plesianthropus transvaalensis* (BROOM). ½ NATURAL SIZE

The molars are badly worn along their outer sides. The canine has its crown ground down quite flat and in line with the other teeth. Parts of the outer sides of the premolars are in the counter slab and will later be replaced

The molars and premolars are much larger than in the Heidelberg jaw, and the canine very much larger. The molars and premolars are much worn. In the case of the 1st and 2nd molars, the whole outer sides of the crowns are worn off; but on the inner side parts of the enamel cusps still remain.

The canine is the most interesting tooth of the jaw. We know the unworn lower canine crown in the male *Plesianthropus*. It is much larger than in man and has a well-developed and pointed main cusp and a small posterior cusp. In the female the upper canine we knew was worn down as in man, but in the male it was suspected that the lower canine passed in front of the upper as in the anthropoid apes. Now we find that the lower canine, while it may in the young animal pass up in front of the upper, is ground down, as age advances, by attrition with the upper, exactly as in man. The whole jaw is thus practically a human jaw.

This jaw is much too large to have fitted the elderly female skull recently discovered; and the skull that belonged to this jaw must have been remarkably large. If a restoration of the skull is made from the known female skull, but large enough to have fitted this jaw, it is seen that we have a skull that is nearly human.

The brain of the female skull was only about 450 c.c., but the male skull that belonged to this jaw must have had a brain of 600 c.c., or perhaps even 700 c.c.

Another interesting point is that on the lower part of the front of the jaw there is a little bony thickening which might be regarded as an incipient chin.

This jaw seems to us to be of considerable importance on the question of man's origin.

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Shape of Hæmocyanin Molecules

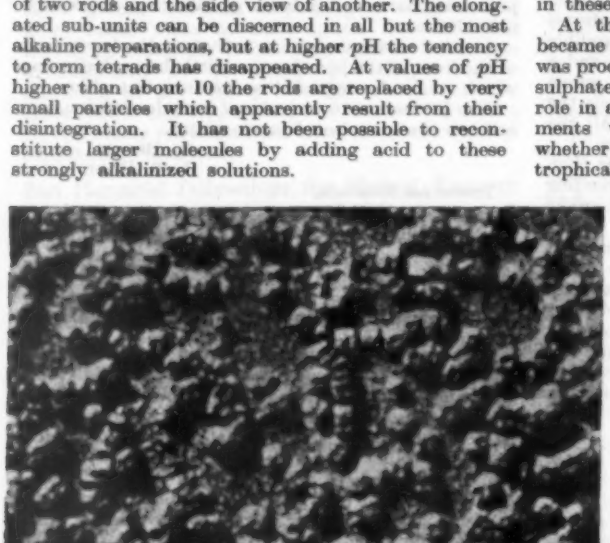
In a previous communication[1] it was shown that the electron microscope can record the individual molecules in a solution of the respiratory protein from *Limulus polyphemus*. An unexplained feature of these photographs was the fact that the diameters of the molecular images were not uniform but showed considerable spread about a mean value. Hæmocyanins from several invertebrates have been under study in this laboratory partly to provide an interpretation of such apparent variation in molecular size and partly to see the reason for the reversible changes in molecular weight that have been established[2] through ultracentrifugal analysis.

Special attention has been given to the hæmocyanin from *Busycon canaliculatum*, living specimens of which were kindly provided by the Fish and Wild Life Service of the U.S. Department of the Interior. This hæmocyanin was selected because of its great molecular weight. Its published *p*H stability diagram records components with sedimentation constants of 130, 102, 61 and 13·5 Svedberg units, the two heavy components being absent at *p*H values above about 9. The principal component in freshly drawn 'blood' seems to be the one with the sedimentation constant 102 and an estimated molecular weight 6,800,000, but the existing data do not record the relative proportions of these components.

Electron micrographs have been made of fresh *Busycon* hæmocyanin and of this protein purified by ultracentrifugation. The *p*H of the solutions was established by adding minimal amounts of phosphate buffer and dialysing against distilled water to remove excess salt. Preparations for electron microscopy were made by putting these solutions and dialysates on the usual collodion-covered screens or by spreading them on glass slides for atomic replication. Shadowing was with gold at a 6–1 angle; photography was carried out with an R.C.A.-type *EMU* instrument.

Sufficiently diluted hæmocyanin near its natural *p*H yields an electron micrograph such as that reproduced herewith. Its single molecular particles are obviously uniform and possess a well-defined internal structure. Careful examination indicates that each large particle consists of rod-like sub-units stacked together, apparently in bundles of four. The

sub-units are about three times as long as they are thick and have pairs, or all four, of their long axes parallel. This gives a cube-like composite particle of constant dimensions. At some places on the photograph the molecules are situated so that one looks down on the ends of four rods; at others the molecules are turned over so that two rods are seen lengthwise. At a few places one pair of rods seems to be rotated 90° with respect to the other, so that a tetrad shows the ends of two rods and the side view of another. The elongated sub-units can be discerned in all but the most alkaline preparations, but at higher *p*H the tendency to form tetrads has disappeared. At values of *p*H higher than about 10 the rods are replaced by very small particles which apparently result from their disintegration. It has not been possible to reconstitute larger molecules by adding acid to these strongly alkalinized solutions.



A GOLD-SHADOWED REPLICA OF A DILUTE SOLUTION OF HÆMOCYANIN FROM *Busycon canaliculatum* SPREAD ON A GLASS SURFACE. INDIVIDUAL MOLECULES ARE THE CUBE-LIKE OBJECTS ABOUT 3 MM. IN DIAMETER. × 77,000

A conspicuous and rather unexpected result of these experiments is the ease with which enough molecular damage can be done to interfere with the orderliness of this particle association. Removal of the last traces of salt by dialysis has brought about this measure of denaturation, and so has treatment with strong salt or purification by repeated sedimentation in the ultracentrifuge. The electron microscope offers an especially sensitive way of studying this type of minimal denaturation.

A detailed investigation is now under way of the molecular structures and stability ranges of fresh solutions of several typical hæmocyanins using both the electron microscope and the analytical ultracentrifuge. Preliminary results already demonstrate that in *Busycon* hæmocyanin undamaged molecules are uniform in size. The largest are regular groupings of smaller rod-shaped units, the associations and dissociations of which are responsible for the different molecular weights determined by the analytical ultracentrifuge.

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[1] Williams, R. C., and Wyckoff, R. W. G., *Nature*, **156**, 68 (1945).
[2] Erikson-Quensel, I-B., and Svedberg, T., *Biol. Bull.*, **71**, 498 (1936).

Autotrophic Growth of Sulphate-Reducing Bacteria

Starkey and Wight[1] have reported reduction of sulphate to sulphide by *impure* cultures of sulphate-reducing bacteria growing in a strictly mineral medium containing sodium bicarbonate as sole carbon source, and in the presence of molecular hydrogen. It was not shown conclusively that pure cultures could grow in these autotrophic conditions.

At the time when Starkey and Wight's report became available in Great Britain (July, 1946) work was proceeding in this Laboratory on pure cultures of sulphate-reducing organisms in connexion with their role in anaerobic microbiological corrosion. Experiments were immediately initiated to determine whether these pure cultures are able to grow autotrophically. Pure cultures of four strains of *Vibrio desulphuricans*, isolated from different sources and exhibiting distinctive morphological characteristics, were subcultured into a medium containing sodium bicarbonate as sole source of carbon, ammonium chloride as nitrogenous nutrient, dipotassium hydrogen phosphate, calcium sulphate, magnesium sulphate, and a trace of ferrous salt. They were incubated at 30° C. in an anaerobic jar containing an atmosphere of hydrogen with 5 per cent carbon dioxide. At first, growth was obtained with one strain only; but successful attempts were made with the other three strains to acclimatize them to growth in media containing gradually decreasing quantities of lactate (the usual source of carbon for heterotrophic growth of sulphate-reducers). This procedure has now been found to be unnecessary, and growth has been obtained with all four strains by direct inoculation into the mineral medium. Growth is accompanied by reduction of sulphate to sulphide, which is clearly shown by precipitation of ferrous sulphide.

In final and conclusive experiments, stringent precautions were taken to ensure the absence of organic material. All glassware used in the preparation of media and for culture vessels was washed in chromic acid and finally in conductivity water. The cotton-wool plugs normally used in medium flasks and in culture test-tubes were replaced by loosely fitting beakers or tubes washed in chromic acid. Pipettes, instead of being wrapped in paper and dry sterilized, were placed inside large glass tubes and autoclaved. The medium was made up with 'Analar' chemicals and conductivity water. Good growth was obtained and has persisted through many subcultures, thus obviating any 'carry-over' effect of organic material from the original inoculant (2 drops). Numerous platings-out on various media incubated both aerobically and anaerobically have shown the cultures to be quite pure at all stages.

Stephenson and Stickland[2] have shown that resting non-proliferating cells of a strain of sulphate-reducing bacteria isolated by them contained an enzyme system capable of causing the reduction of sulphate to sulphide by means of molecular hydrogen. They found that the hydrogen absorbed was equivalent to the sulphate reduced and the hydrogen sulphide formed. Under their experimental conditions no growth occurred; but presumably the energy for

autotrophic growth of the four strains is obtained by the oxidation of hydrogen brought about by the same or similar enzyme system. As one would expect, all attempts to cultivate the strains anaerobically in the mineral medium alone, in the absence of hydrogen, have failed. When, however, rods of carefully cleaned sterile mild steel are placed in the inoculated mineral medium and incubated at 30° C. in a closed jar containing alkaline pyrogallol for absorption of oxygen, definite growth occurs with reduction of sulphate to sulphide. As suggested by Starkey and Wight[1], who obtained similar results with contaminated cultures, it is probable that hydrogen is formed by reaction of the steel with water, and its oxidation supplies the energy for growth.

Similar autotrophic growth, both in mineral salt solution with hydrogen atmosphere and in mineral salt solution with immersed steel rod, has been obtained with a thermophilic strain of sulphate-reducers at 55° C.

It can therefore be concluded, in the light of Starkey and Wight's and our own experiments, that sulphate-reducing bacteria may be regarded as facultative autotrophs.

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Gonads and Experimental Tuberculosis

Results, obtained to date, by different authors on the investigation of the influence of the sexual organs in experimental tuberculosis vary very much indeed. Mautner[1] and Bricker[2] admit that castration prolongs the life of the inoculated animals, whereas Brack and Gray[3] and Long and Vogt[4] deny such results. Vercesi and Merenda[5], Gray and Brack[6] and Long and Vogt[4] maintain that injection of œstrogens does not modify the course of experimental tuberculosis. Carnes and Biskind[7], who administered testosterone, reach the same conclusion. Most of these investigations have been carried out with very small groups of animals, and in others the results have been observed a few days after the inoculation; thus it has not been possible to define with precision the reaction of the animals to the tuberculous infection. Studies were carried out by us in the guinea pig to establish not only the type of pathological lesions, but also the survival-rate of the animals. These animals were grouped in the following manner: 20 castrated animals, 10 males and 10 females; 20 non-castrated females, which were injected intraperitoneally with 50 μgm. of œstradiol dipropionate three times a week; 20 non-castrated males, injected intraperitoneally with 250 μgm. of testosterone propionate three times a week; 20 control animals. All these animals were injected subcutaneously with 1 c.c. of an emulsion which contained 0·1 mgm. of tubercle bacilli of the human type.

The castrated guinea pigs showed an increased survival-rate as compared with the controls. During the course of the second month 10 per cent of the castrated animals had died, as compared to 30 per cent of the control group. In the fourth month 35 per cent of the castrated animals had died, as compared with 90 per cent of the controls. In the seventh month all the control group had died, as against only 60 per cent of the castrated group.

The pathological lesions found were characteristic of fibrocaseous involvement, whereas in the castrated animals there was a tendency towards lesions of the fibrous type. Animals injected with œstradiol or testosterone showed identical mortality figures with those of the control group; but the lesions were much more extensive and of the caseous type. The influence of the gonads on tuberculosis could be explained by the indirect action that the hypophysis exerts on the thyroid. Castration produces in the hypophysis specific reactions in the basophilic cells, which in turn would augment the stimulating action of the hypophysis on the thyroid. The fact that we have found[8] that castrated animals are hypersensitive to thyroxin seems to establish a basis for this reasoning. Contrary to what happens in castrated animals, the injections of œstrogen or testosterone show an inhibiting action on the hypophysis, which could induce a state of hypothyroidism.

Thus we find that the thyroid influences the course of experimental tuberculosis; thyroxin increases the survival-rate, whereas thyroidectomy has an opposing action.

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[1] Mautner, H., *Monatsch. Kinderheilk.*, **21**, 38 (1921).
[2] Bricker, F. M., *Z. Tuberk.*, **40**, 198 (1924).
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Cultivation of the Erythrocytic Form of *Plasmodium gallinaceum* in Tissue Cultures of Embryonic Chicken Brain

In previous experiments a method was found for the cultivation of the exoerythrocytic form of *Plasmodium gallinaceum* in tissue cultures of embryonic chicken brain. It was found that proliferation of the parasites in tissue culture cells is very slow, and that the initial stages are difficult to observe *in vivo* and also in the stained cultures. Parasites were still found after 134 days of cultivation in tissue cultures.

On account of the slowness of the proliferation and the difficulty of observing the initial stages of the parasite, we repeated experiments on the cultivation of the form of the parasite found in the blood, which formerly were carried out without result, perhaps because insufficient time was given and also because of inability to recognize the early stages in the cells.

We cultivated embryonic chicken brain together with a drop of highly infected chicken blood, first, for some time in Carrel flasks, and passing later to the hanging drop method. With this technique and the better knowledge of the initial stages of the parasites in the cells, we have observed parasitized cells after three or four weeks of cultivation. The

parasites in these cultures had the same form as those in cultures of the exoerythrocytic form.

Details and colour photomicrographs of the infected cells will be presented in the complete publication of this work, which will be sent to *Revista Brasileira de Biologia*.

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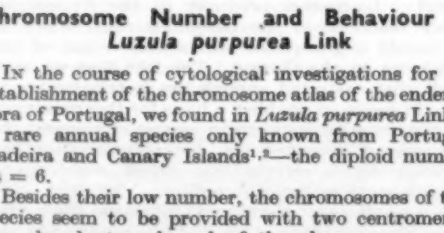
Chromosome Number and Behaviour in *Luzula purpurea* Link

IN the course of cytological investigations for the establishment of the chromosome atlas of the endemic flora of Portugal, we found in *Luzula purpurea* Link—a rare annual species only known from Portugal, Madeira and Canary Islands[1,2]—the diploid number $2n = 6$.

Besides their low number, the chromosomes of this species seem to be provided with two centromeres, one placed at each end of the chromosome. No median, sub-median or sub-terminal constriction could be distinguished either in mitotic or meiotic metaphases.

In anaphase figures both mitotic and meiotic the chromosomes take the shape of a U with their ends turned to the poles and not that of an inverted V as it normally occurs (see accompanying photographs).



This appears to be the first time such chromosome behaviour has been found in plants, and we think it may be related to what Toledo Piza[3] reported for the Brazilian scorpion *Tityus bayensis* Perty and for some Hemiptera[4]. Schrader[5], Hughes-Schrader and Ris[6], and Ris[7], working also with Hemiptera, found what they called "diffuse centromeres". This may be also the expression of a common behaviour.

A detailed description of the meiosis of *Luzula purpurea* will soon be published.

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Estaçao Agronómica Nacional,
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May 6.

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Mortality of *Aedes ægypti* Feeding on Rabbits Receiving Oral 'Gammexane'

LINDQUIST *et al.*[1] discovered the toxicity to bed bugs of the blood of rabbits fed on D.D.T., and de Meillon[2] has recently reported the action of 'Gammexane' in regard to mosquitoes. This communication describes a series of tests to elicit the minimum lethal dose of 'Gammexane' in similar circumstances, and the period during which the effect lasts.

The mosquitoes came from an *Aedes ægypti* colony, and were reared and stored in a constant-temperature room of 80°–85° F. in a humidity of 70 per cent. The tests were carried out in the same room; 72-hr. old unfed females were used. The 'Gammexane' was given in the form of a 5·5 per cent solution in rectified spirits, either in a capsule or more conveniently by pipette directly down the throat of the rabbit. Then, at different intervals, the mosquitoes were allowed to feed on the rabbits' ears, and those which fed were collected and stored in cages for 24 hr., when the dead were counted. Unfed specimens were discarded. Prior to the administration of the 'Gammexane', a control group of mosquitoes were fed on the animal, and the mortality was observed after 24 hr.

Two series of tests were conducted, the first to ascertain the minimum lethal dose during the first seven hours and at 24 hr., and the second to observe for how many days the insecticidal effect persisted. The results are shown in Tables 1 and 2 respectively.

TABLE 1. LETHAL ACTION OF 'GAMMEXANE' DURING FIRST 24 HR.

Dose of 'Gammexane'* (mgm. per kgm.)	Control		Hours after administration of 'Gammexane'				
	Number fed	Number alive after 24 hr.	Numbers fed and deaths after 24 hr.				
			1½	3	5	7	24
40	10	9	2:2	6:6	6:6	4:4	1:1
40	15	15	10:10	14:14	20:20	16:16	6:6
30	14	13	9:9	8:8	5:5	6:6	5:5
25	11	11	8:6	6:6	4:4	3:3	3:3
25	6	6	5:5	9:9	6:6	4:4	3:3
20	7	7	7:5	7:7	9:9	6:6	4:4
15	10	10	10:10	8:7	6:4	8:7	6:6
10	10	10	—	7:0	2:1	4:3	16:9

* 'Gammexane' = γ isomer.

TABLE 2. LETHAL ACTION OF 'GAMMEXANE' DURING WEEK AFTER ADMINISTRATION

Dose of 'Gammexane'* (mgm. per kgm.)	Control		Days after administration of 'Gammexane'					
	Number fed	Number alive after 24 hr.	Numbers fed and deaths after 24 hr.					
			1	2	3	4	5	6
40	9	9	—	6:6	7:7	8:8	16:3	10:0
30	8	8	10:10	15:15	9:9	8:0	5:0	—
25	12	12	5:5	5:5	13:5	3:0	4:0	—
25	11	11	3:3	4:4	2:2	2:1	—	3:0
15	10	10	6:6	5:5	—	—	—	—

* 'Gammexane' = γ isomer.

The minimum lethal insecticidal dose appeared to be between 25 and 30 mgm. of 'Gammexane' per kgm. of rabbit, though even dosages of 15 mgm. gave a partial mortality. The figures suggest that the concentration of 'Gammexane' in the blood rises for 24 hr.; thus, with the lower dosages, mosquito mortality is incomplete at first, whereas if the insects are fed later in the 24 hr. all may die.

The persistence of the lethal action after a single dose varies according to the amount of 'Gammexane' administered. The maximum period for a complete kill was four days following a dose of 40 mgm. With lower amounts, the effect lasted only two days. The lethal action disappeared rapidly at the conclusion of these periods of complete mortality.

The final reading of deaths was always taken after 24 hr.; as a rule, most of the mosquitoes were 'down' three hours after feeding.

It is doubtful if the dosage could be increased much beyond 40 mgm. per kgm., for even with that amount several of the rabbits died in convulsions.

The number of mosquitoes used in the tests was rather small, chiefly because the insects showed a reluctance to feed on an animal treated with 'Gammexane'. Very often 50 had to be used in order to get 10 to take enough blood for a test, whereas with a normal rabbit practically all would feed.

The amount of blood imbibed by an *Aedes ægypti* was determined by weighing specimens on a torsion balance before and after feeding. The average weight of 30 unfed 72-hr. old females was 2·04 mgm. (± 0·3 mgm.); after feeding on a rabbit treated with 'Gammexane' the weight was 4·56 mgm. (20 specimens), representing a gain of 2·52 mgm. of insecticidal blood. On a normal rabbit the mosquitoes gorge more fully, and the average gain of weight with them was 4·16 mgm.

These results rather indicate that, so far as *Aedes ægypti* mosquitoes are concerned, the method has little practical application; first, because the effect lasts only for four days, and secondly, because the mosquitoes apparently dislike feeding on an animal treated with 'Gammexane'. The action of the insecticide, however, is powerful and is 100 per cent effective while it lasts.

I have pleasure in thanking my assistant, Mr. J. C. Pyefinch, for much practical help in carrying out the tests.

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[1] Lindquist, A. W., Knipling, E. F., Jones, H. A., and Madden, A. H., *J. Econ. Entomol.*, 39 (1946).
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Frenkel's Views on the Origin of Terrestrial Magnetism

J. Frenkel has recently put forward[1] a theory of the origin of terrestrial magnetism that depends on the field being maintained by the electric currents induced in the liquid metallic core of the earth by the thermal convection of the material of the core.

Theories that ascribe the earth's magnetic field to motions in the core are attractive as, so far as is known, they provide the only possibility of explaining changes in times of the order of a century. Unfortunately, Frenkel's argument appears to contain faults which invalidate it.

Frenkel notes that free convection would occur in the core if the thermal gradient exceeded the adiabatic gradient, and shows that the rate of heat generation required (about 10^{-7} erg./cm.³/sec.) is much below that produced by the radioactivity of surface rocks. However, the iron core model postulated is more appropriately to be compared in composition with iron meteorites than with surface rocks. Six iron meteorites analysed for uranium and thorium by Paneth[2] give an average heat generation of $4{\cdot}2 \times 10^{-6}$ erg./cm.³/sec., which is not quite so much as Frenkel requires. This, however, is a minor point, as the theoretical value is subject to great uncertainty, and the experimental results are of doubtful relevance.

Frenkel assumes that the convective motion will be in paths of a size comparable with the radius of the core, and shows that if the viscosity is taken as 0·01 gm./cm.sec., velocities comparable with that of light will be generated. He concludes from this that viscosity is not able to control the convection currents and maintain reasonable velocities, and that the control must be by a dynamo action, of the kind suggested by Larmor. The system is supposed to approximate to an ideal thermodynamic engine for changing heat energy into electric currents. In fact, the Reynolds' number of the motion considered is about 10^9, and turbulent motion would certainly ensue, increasing the velocity gradients and enabling viscosity to control the motion. The viscosity assumed may well be too low, but if it is increased to obtain stability for the large-scale motion, the possibilities of energy dissipation in this motion will be increased. The hydrodynamic theory of a convecting core would repay detailed investigation.

No reference is made by Frenkel to Cowling's demonstration[3] that self-maintenance of a steady magnetic field by fluid motions with axial symmetry is impossible. Unless some way can be found of avoiding this theorem, all theories of the kind considered by Frenkel seem necessarily to fail in spite of their other attractions.

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Relation Between the Intensity of Solar Radiation on 175 Mc./s. and 80 Mc./s.

In a previous communication[1] we described some experiments on electromagnetic radiation emitted from the sun on a frequency of 175 Mc./s. In the present note we give some results, obtained during the period December 1946–April 1947, of observations in which the same technique has been used to obtain simultaneous records of the intensity of solar radiation on the two frequencies of 175 Mc./s. and 80 Mc./s.

During periods of increased activity the radiation is characterized by the presence of short-lived 'bursts' of radiation having an intensity up to five times the mean value, and lasting from one to twenty seconds. An examination of the records shows that there is apparently no correlation between the times of occurrence of bursts of this type on the two frequencies. A section of a typical record is shown in Fig. 1. (The alteration of mean intensity recorded in this figure is due to the use of a pair of aerials as explained earlier[1].)

At times, however, very much larger bursts occur, having intensities as great as 20 or even 100 times

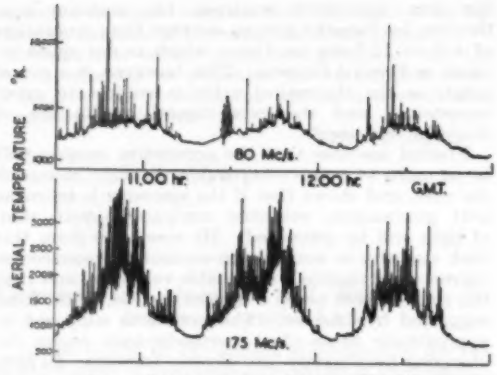

Fig. 1. SOLAR RADIATION, JANUARY 22, 1947

the mean value, and these may persist for many minutes. These larger bursts are usually observed on both frequencies, and many are accompanied by other evidence of solar activity, such as the observation of solar flares, or radio fade-outs.

The production of such short-lived bursts of high intensity is presumably due to a temporarily increased effective temperature of the source. The lack of coincidence between bursts observed on the two frequencies, therefore, suggests that radiation on these two frequencies originates in different regions, and that only during periods of great activity are both regions affected by the same sudden disturbance.

In addition to these short-lived bursts of radiation, the day-to-day variation of the intensity on the two frequencies has been investigated. The mean value during the four midday hours of each day has been plotted, for the period December 14–April 22, in Fig. 2. The intensities are expressed in terms of the equivalent temperature of a black-body source subtending an angle of $\frac{1}{4}°$.

It can be seen that, while these curves show some evidence for variations with a period of 27 days (as would be expected from the movement of an active area across the sun's disk), there are other large-amplitude fluctuations of an apparently random nature.

In Fig. 3, the ratio of the equivalent temperatures of the source (T_{80}/T_{175}) has been plotted, and it is interesting to note that while the range of fluctuations is still of the order 4 : 1, it is considerably less than the range of fluctuations of the equivalent

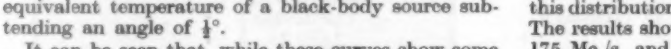

Fig. 2. DAY-TO-DAY VARIATION OF SOLAR RADIATION ON 80 MC./S. AND 175 MC./S.

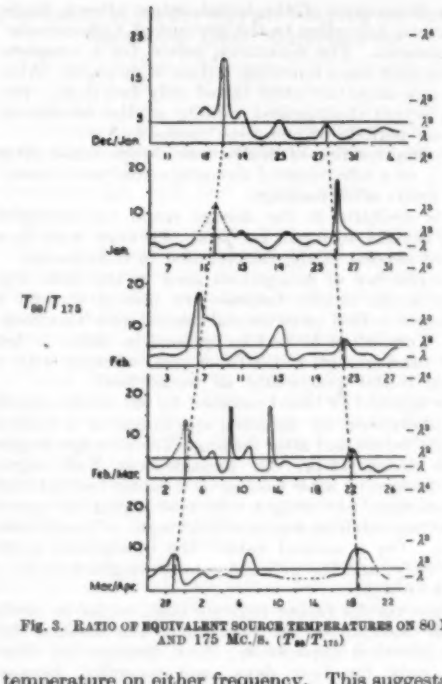

Fig. 3. RATIO OF EQUIVALENT SOURCE TEMPERATURES ON 80 MC./S. AND 175 MC./S. (T_{80}/T_{175})

temperature on either frequency. This suggests that the day-to-day variations of intensity on the two frequencies are to some extent related.

It has been suggested by Appleton and Hey[2] that there is a definite wave-length – intensity distribution for the increased radiation emitted during periods of solar activity, and that observed departures from this distribution are the result of ionospheric influence. The results shown in Figs. 2 and 3 for frequencies of 175 Mc./s. and 80 Mc./s. (which cannot be affected appreciably by the ionosphere) indicate that whereas the general level is consistent with an equivalent temperature which varies as λ^2, there are marked departures from this relation on many days.

An examination of Fig. 3 shows that the occasions when the ratio of the intensities departs appreciably from the average tend to recur with a period of about 27 days, in a manner far more marked than the variations of intensity on either frequency alone. Our results, therefore, suggest that when the ratio of the intensities on the two frequencies assumes abnormal values, it is due to directed emission, the angular distribution of which is different for the two frequencies.

If the recurrence tendency detectable in Fig. 3 is substantiated by further measurements, it seems probable that the day-to-day variations of the intensity of solar radiation are partly due to directed emission with a 'polar diagram' which is a function of frequency, and partly due to variation of the effective temperature or the area of the source, which appears to be largely independent of frequency.

The curve also suggests that there may be periodicities of 28, 27 and 26·3 days. These may be due to radiation from active regions at different solar latitudes.

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[2] Appleton and Hey, *Phil. Mag.*, **37**, 73 (1946).

Absorption Bands of Li_2, Na_2, K_2 and NaK

Although fairly complete information is available regarding the first two systems of bands of Li_2, Na_2 and K_2, the position with regard to the higher systems cannot yet be considered satisfactory. For this reason the spectra of these alkali-metal molecules, in the regions corresponding to the third, fourth and higher systems of bands, have been investigated in absorption, employing a quartz E_1 spectrograph for lithium, and a 21-ft. concave grating (Eagle mounting), having a dispersion of 1·3 A. per mm., for sodium and potassium. A hydrogen discharge tube has been used as source of continuum below λ 3600 and a tungsten lamp above that.

Li_2: The ultra-violet spectrum of Li_2 has been previously investigated by Vance and Huffman[1]. The bands lie between λ 3500 and λ 3100, and are regarded by them as belonging to four different systems. These, however, appear fragmentary. In the present investigation, the bands have been found to appear most satisfactorily at a temperature of about 1,000° C., using argon gas at a pressure of about half an atmosphere inside the absorption tube to prevent rapid distillation of the metal to cooler parts. Bands appear between λ 6900 and λ 3100, but the heads can be marked clearly only between λ 3500 and λ 3100. All the heads measured are found to belong to a single system represented by the equation:

$$\nu = 30658{\cdot}5 + 231{\cdot}5\,(v' + \tfrac{1}{2}) - 1{\cdot}5\,(v' + \tfrac{1}{2})^2 - 351{\cdot}6\,(v'' + \tfrac{1}{2}) + 2{\cdot}6\,(v'' + \tfrac{1}{2})^2.$$

The upper state of this system is considered to dissociate into $2\ ^2S + 3\ ^2P$ atoms. No evidence for other systems is found. The few additional band heads which led Vance and Huffman to conclude that as many as three more systems of bands exist in this region have not been observed in the present investigation. It is difficult to assign any definite reason for their measuring these band heads, as they have not published any value for the intensity of their bands. Another consideration which made them think that there was a case for several systems of bands of Li_2 in this region was analogy with the case of Na_2 which was formerly regarded as having three systems of bands in the corresponding region, namely, λ 3600–λ 3200. This, too, has been disproved, both in previous work[2] and in the present investigation. It seems, therefore, that the Li_2 bands between λ 3500 and λ 3100 really belong to a single system.

Na_2: The sodium molecule has bands in the ultra-violet region extending from about λ 3650 to about λ 2500, which are considered to belong to several systems[2]. Only the bands between λ 3600 and λ 3200 have been photographed in the present investigation for more accurate study. These bands appear well developed at a temperature of about 750° C., using nitrogen or some inert gas in the absorption tube at a pressure of about 5 cm. of mercury. The bands belong to a single system, and their heads can be represented by the equation

$$\nu = 29342{\cdot}0 + 119{\cdot}33\,(v' + \tfrac{1}{2}) - 0{\cdot}53\,(v' + \tfrac{1}{2})^2 - 159{\cdot}23\,(v'' + \tfrac{1}{2}) + 0{\cdot}726\,(v'' + \tfrac{1}{2})^2 + 0{\cdot}0027\,(v'' + \tfrac{1}{2})^3.$$

The upper state of this system of bands is considered to dissociate into $3\ ^2S + 4\ ^2P$ atoms. The rotational structure of a few bands of this system has also been studied. This indicates that the bands have only two branches and are, therefore, due to $^1\Sigma_u^+ \leftarrow {}^1\Sigma_g^+$ transition. The values of B and r for the upper state are 0·1065 cm.$^{-1}$ and 3·70 A. respectively. It has not been possible to calculate the other constants such as D and α, for which higher dispersion would be necessary.

K_2: The K_2 molecule has been reported to possess bands in the blue and the ultra-violet region down to about λ 3,000[3-5]. Only the bands between λ 4520 and λ 3940 have been studied in the present investigation. The bands belong to two systems: (i) λ 4520–λ 4200; and (ii) λ 4160–λ 3940. The band heads of the first system can be represented by the equation

$$\nu = 22970{\cdot}0 + 60{\cdot}60\,(v' + \tfrac{1}{2}) - 0{\cdot}20\,(v' + \tfrac{1}{2})^2 - 92{\cdot}64\,(v'' + \tfrac{1}{2}) + 0{\cdot}354\,(v'' + \tfrac{1}{2})^2,$$

and its upper state is considered to dissociate into $4\ ^2S + 5\ ^2P$ atoms. The heads of the second system can be represented by

$$\nu = 24627{\cdot}7 + 61{\cdot}60\,(v' + \tfrac{1}{2}) - 0{\cdot}90\,(v' + \tfrac{1}{2})^2 + 0{\cdot}001\,(v' + \tfrac{1}{2})^3 - 0{\cdot}003\,(v' + \tfrac{1}{2})^4 - 92{\cdot}64\,(v'' + \tfrac{1}{2}) + 0{\cdot}354\,(v'' + \tfrac{1}{2})^2,$$

with its upper state dissociating into $4\ ^2S + 4\ ^2D$ atoms. The K_2 bands between λ 4160 and λ 3940 were previously considered to belong to two different systems[4]. It has been found that even the previous measurements which were attributed to two systems can be combined into a single system, if due allowance is made for some missing bands due to the broadening of the principal series doublet at λ 4045.

NaK: A system of NaK bands in the ultra-violet region between λ 4020 and λ 3540 has been reported by Walter and Barratt[6] and analysed in different ways by Weizel and Kulp[7] and by Uchida[8]. These bands have also been photographed in course of the present investigation on the 21-ft. grating. It has been found that only the bands between λ 4080 and λ 3820 are due to NaK, while the rest of the strong bands of Walter and Barratt which lie between λ 3660 and λ 3540 are due to Na_2. The band heads in the former region can be represented by the equation

$$\nu = 25201{\cdot}0 + 95{\cdot}85\,(v' + \tfrac{1}{2}) - 0{\cdot}94\,(v' + \tfrac{1}{2})^2 - 123{\cdot}29\,(v'' + \tfrac{1}{2}) + 0{\cdot}40\,(v'' + \tfrac{1}{2})^2.$$

The upper state of this system is considered to dissociate into Na $3\ ^2S$ + K $4\ ^2D$ atoms.

Full details will be communicated elsewhere.

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Spherical Electronic Waves ?

THE electronic A-waves which were predicted in a recent communication[1] were plane waves, and it is very difficult to picture them. It seems, moreover, that these would be indefinitely extended.

Consider the possibility, therefore, of a spherical wave of the form

$$\mathbf{A} = \frac{e\mathbf{v}'}{cr}\,\psi\left(t - \frac{s}{\mathbf{u}}\right). \qquad (1)$$

It will be noticed that the phase velocity is still $\mathbf{u} = c^2/\mathbf{v}$, but that outside the wave function ψ we have now included a factor similar to the known expression for **A** as excited by a point charge, $\mathbf{v}'$ being the velocity of the 'exciting' electron, **v**, **u** appertaining to the 'exploring' electron. We then find, proceeding as before, that

$$\nabla\mathbf{A} + \frac{\dot{\mathbf{A}}}{\mathbf{u}} = -\frac{e\mathbf{v}'_r}{cr^2}\,\psi\left(t - \frac{s}{\mathbf{u}}\right) + \frac{e\mathbf{f}'}{cr\mathbf{u}}\cdot\psi\left(t - \frac{s}{\mathbf{u}}\right)\cdot\frac{dt'}{dt}, \qquad (2)$$

where $\mathbf{f}'$ is $d\mathbf{v}'/dt'$. The condition that the left-hand side of (2) vanish is

$$\mathbf{f}' = \frac{\mathbf{u}v'_r}{r}\cdot\frac{dt}{dt'}. \qquad (3)$$

This would be a very great acceleration, and we infer that (3) is not practicable. In the case $\mathbf{f}' = 0$ (uniform speed of exciting electrons) (2) may be written

$$\nabla\mathbf{A} + \frac{\dot{\mathbf{A}}}{\mathbf{u}} = -\frac{A_r}{r}. \qquad (4)$$

The left-hand side may be replaced[1], giving

$$\frac{d}{dt}\left(\frac{m\mathbf{v}^2}{2} + e\varphi\right) = -\frac{A_r}{r}. \qquad (5)$$

If A_r is positive (5) gives a decreasing total energy, which means radiation from the exploring electrons; very small, however, as we shall see.

Now when we take into account relativistic changes in mass[2], we require to replace $m\mathbf{v}^2/2$ by mc^2 in (5). For the first term of (5) would become

$$\mathbf{v}\frac{d}{dt}(m\mathbf{v}) = \mathbf{v}\frac{d}{dt}\left[\frac{m_0\mathbf{v}}{(1 - \mathbf{v}^2/c^2)^{1/2}}\right] = \frac{m_0\mathbf{v}\,d\mathbf{v}/dt}{(1 - \mathbf{v}^2/c^2)^{3/2}} = \frac{d}{dt}(mc^2); \qquad (6)$$

when this is done (9) of the previous note becomes

$$m\mathbf{v}\dot{\mathbf{v}} + e\dot{\varphi}\,(1 - \mathbf{v}^2/c^2) = 0,$$

and this leads to

$$\dot{\mathbf{p}} = \frac{\mathbf{v}^2}{c^2}\,\dot{\mathbf{p}}_\mu \qquad (7)$$

instead of to $\dot{\mathbf{p}} = 0$, where $\mathbf{p}_\mu = e\mathbf{A}/c$.
Now from (1)

$$\dot{\mathbf{p}}_\mu = \frac{e}{c}\,\dot{\mathbf{A}} = \frac{e^2}{c^2r}\,(\dot{\mathbf{v}}'\psi + \mathbf{v}'\dot{\psi}).$$

Thus $m\dot{\mathbf{v}} = \dot{\mathbf{p}} - \dot{\mathbf{p}}_\mu = \left(\frac{\mathbf{v}^2}{c^2} - 1\right)\dot{\mathbf{p}}_\mu = \left(\frac{\mathbf{v}^2}{c^2} - 1\right)\frac{e}{c}\dot{\mathbf{A}}$

$$= e^2\,\frac{(\mathbf{v}^2 - c^2)}{c^4r}\left(\dot{\mathbf{v}}'\psi + \mathbf{v}'\dot{\psi}\right). \qquad (8)$$

For a stream of electrons all having substantially the same velocity, take $\mathbf{v}' = \mathbf{v}$.

$$\dot{\mathbf{v}}\left[1 + \frac{e^2}{mc^2r}\,\psi\cdot\left(1 - \frac{\mathbf{v}^2}{c^2}\right)\right] = \frac{-e^2}{mc^2r}\left[\left(1 - \frac{\mathbf{v}^2}{c^2}\right)\mathbf{v}\dot{\psi}\right]. \qquad (9)$$

While solving the equation let us take $1 - \mathbf{v}^2/c^2$ as unity. We then obtain to the second order

$$\mathbf{v} = \bar{\mathbf{v}}/\left(1 + \frac{e^2}{mc^2r}\,\psi\right), \qquad (10)$$

where $\bar{\mathbf{v}}$ is the non-wave-like uniform part of **v**. The component of **v** in the direction of r is obtained by replacing **v** by v_r, so that

$$\frac{A_r}{r} = \frac{e\bar{v}_r}{cr^2}\,\frac{\psi}{1 + \frac{e^2\psi}{mc^2r}} = \frac{e\bar{v}_r}{cr^2}\left(\psi - \frac{e^2}{mc^2r}\,\psi^2\right), \qquad (11)$$

to the degree of accuracy to which we are working. In view of the minus sign in (5), (11) gives the rate of radiation of electromagnetic energy by the exploring electron (for slowly moving electrons).

The time average of this expression is

$$\left(\frac{\bar{A}_r}{r}\right) = -\frac{1}{2}\cdot\frac{ev_r}{cr^2}\cdot\frac{e^2}{mc^2}\,\psi\psi^*, \qquad (12)$$

which is a third-order quantity, as one would expect of electromagnetic radiation. The rate of radiation as expressed by (12) differs from normal, however, in (at least) the following respects.

(*a*) It changes sign with e, being positive for electrons and negative for positrons or protons.

(*b*) It is a maximum if the radiating electron be moving in line with the point of observation.

(*c*) Its absolute value is insignificant except for values of r not greatly exceeding atomic dimensions.

In view of (*c*) any impairment in the energy of the beam would be too small to give rise to observable effects, except when the beam is brought into close contact with matter.

The main point of the present note is to establish that by extending the results of the previous communication to the physically more probable case of spherical waves, the loss of energy in the beam is insufficient to show on instruments, except when the beam is brought into close contact with matter.

The condition

$$d/dt\,(mc^2 + e\varphi) = 0 \qquad (13)$$

is satisfied to a sufficient degree of approximation for the beam to appear of constant velocity when moving in a space substantially force-free. In particular, a cathode ray beam *in vacuo* would not be slowed down to a noticeable extent. We may, therefore, regard classical (Lorentz) electrodynamics as probably capable of explaining electronic waves, apart from assigning the phase of the wave, which involves Planck's constant.

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April 4.

[1] *Nature*, **156**, 204 (1945).
[2] A. G. D. Watson, of A.S.E., in a letter to me dated Sept. 22, 1945, gave an alternative proof of (6).

Constitution of the Irradiation Product from Stilbamidine

FOLLOWING the observation by Fulton and Yorke[1] that the drug stilbamidine (4 : 4′-diamidinostilbene di-β-hydroxyethanesulphonate) undergoes photochemical change with production of a more toxic substance when its solutions are exposed to light, various investigators have put forward suggestions regarding the constitution of the irradiation product. Barber, Slack and Wien[2] reported that "The product is almost certainly 4 : 4′-diamidinophenylbenzyl carbinol, but rigorous proof is difficult". Goodwin[3], from spectrographic evidence, confirmed that saturation of the ethylenic linkage occurs, while Henry[4] reported that a number of chemical changes are involved, including dimerization.

On exposing a solution of stilbene in benzene for a long period to sunlight, Ciamician and Silber[5] isolated a hydrocarbon of m.p. 163° which from analysis and molecular weight determinations they considered to be a dimer of stilbene $C_{28}H_{24}$. This substance has been prepared in the present investigation by irradiating a similar solution with the light from a mercury vapour lamp, and has been used as a reference compound to show that the product of irradiation of stilbamidine is also a dimer, namely, 1 : 2 : 3 : 4-tetra-(4′-amidinophenyl)-*cyclo*butane. After irradiation of stilbamidine, the toxic product formed was isolated and purified as the sulphate. By hydrolysis with alcoholic potassium hydroxide it was converted to the corresponding tetra-acid which, on decarboxylation, gave the hydrocarbon m.p. 163° mentioned above, along with a small amount of another hydrocarbon of the same empirical composition and m.p. 149°.

The identity of the hydrocarbon m.p. 163° obtained by Ciamician and Silber with that obtained by decarboxylation of the tetra-acid was shown by the fact that both substances gave the same X-ray diffraction patterns. The second hydrocarbon m.p. 149° gave, on the other hand, quite different X-ray patterns. The X-ray data are as follows :

Melting point Crystal system	163 °C. Monoclinic	149° C. Monoclinic
a, Å	16·99 ± 0·10	20·45 ± 0·10
b, Å	5·775 ± 0·02	9·40 ± 0·05
c, Å	12·33 ± 0·08	10·77 ± 0·05
β°	127·0 ± 0·5	92·0 ± 1·0
Space group	P_{2_1}/a (C_{2h}^5)	P_{2_1}/a (C_{2h}^5)
Density (gm./c.c.) at 18° C.	1·23	1·14

For the hydrocarbon m.p. 163°, the observed density is consistent with the unit cell containing four asymmetric units $C_{14}H_{12}$; if these are grouped in pairs to form two molecules of $C_{28}H_{24}$, the resulting molecules must possess centres of symmetry. This is, in fact, the case, as has been shown by a fairly detailed X-ray analysis which shows that this substance is the centro-symmetric isomer of 1 : 2 : 3 : 4-tetraphenyl*cyclo*butane.

For the hydrocarbon m.p. 149°, the asymmetric crystal unit is the molecule, $C_{28}H_{24}$. This molecule may possess elements of symmetry, but these are not, as in the former compound, demanded crystallographically. We believe that this compound is the second isomer theoretically obtainable by dimerization of stilbene, namely, with a fourfold alternating axis of symmetry, but we have at present no evidence.

For the X-ray structure determination of the hydrocarbon $C_{28}H_{24}$ m.p. 163°, no direct analysis is possible, and trial methods were used in the preliminary stages. The method described by Robertson and White[6], involving the use of the small spacing planes with outstandingly strong spectra, gave an early approximation to the structure, which was then refined by three successive Fourier projections on (010) and a Fourier projection on (100). The final projection on (010) is shown in Fig. 1. While it is hoped to refine this analysis further by three-dimensional methods, certain interesting features of the structure are apparent at the present stage.

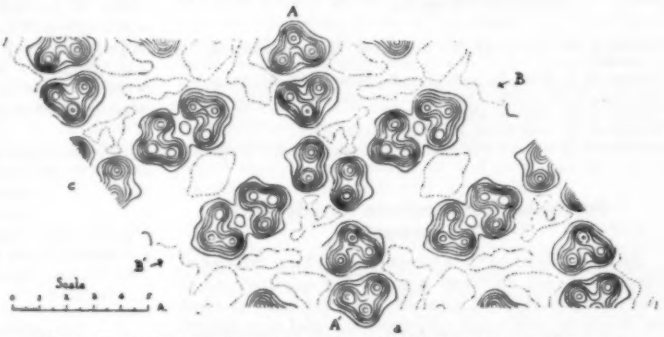

Fig. 1. THE CENTROSYMMETRIC ISOMER OF 1 : 2 : 3 : 4-TETRAPHENYL*cyclo*BUTANE. FOURIER PROJECTION ON (010), SHOWING ONE UNIT CELL

The projection on (010) (Fig. 1) shows clearly that the molecule is indeed 1 : 2 : 3 : 4-tetraphenyl*cyclo*butane ; and the orientation of the phenyl groups about the central ring is diagrammatically shown in Fig. 2, where the benzene rings A,A', B,B' are as indicated in Fig. 1.

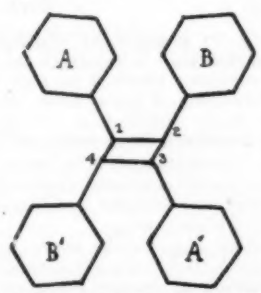

Fig. 2. DIAGRAMMATIC REPRESENTATION OF THE MOLECULE

The configuration about 1–2, 3–4 is *cis*-, while about 2–3, 1–4 it is *trans*-, and the different steric relationships of the phenyl groups about these bonds appear to be associated with considerable distortion of the cyclobutane ring. The ring is necessarily planar (owing to the presence of the centre of symmetry), but it is found to be rectangular rather than square. The observed dimensions are 1·63 A. for 1–2 and 2–3, 1·49 A. for 2–3 and 1–4, and 2·21 A. for the diagonals.

The value 1·63 A. is considerably larger than the normal carbon–carbon single-bond distance 1·54 A., but it is unlikely that it is subject to an error of more than 0·05 A. The other interatomic distances

observed are approximately as expected; the benzene rings are found to be regular hexagons of side 1·39 A. (to within 0·03 A.), and the bonds connecting the benzene rings to the *cyclo*butane ring measure 1·52 A. At the present stage of the analysis, however, it would be virtually impossible to reconcile the data obtained with a square central ring.

In the second isomer, m.p. 149°, no distortion of the *cyclo*butane ring is expected to occur, but structure analysis has not so far been carried out for this substance.

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[1] Fulton, J. D., and Yorke, W., *Ann. Trop. Med. Parasitol.*, **36**, 134 (1942).
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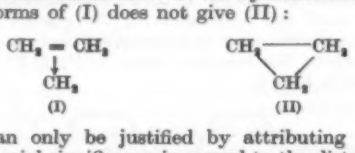
[4] Henry, A. J., *Nature*, **152**, 690 (1943).
[5] Ciamician, G., and Silber, P., *Ber.*, **35**, 4128 (1902).
[6] Robertson, J. M., and White, J. G., *J. Chem. Soc.*, 607 (1945).

Formulæ for Ethylene Oxide and Cyclopropane

DR. A. D. WALSH[1] has misunderstood my criticism[2], which was not directed against his applications of wave mechanics but against the proposed symbols for ethylene oxide and cyclopropane and also against his statements relating to the reaction types of these substances. His further elaborations are of great intrinsic interest but irrelevant to the issues mentioned.

Dr. Walsh maintains that the hybridization of the three forms of (I) does not give (II):



(I) (II)

That can only be justified by attributing to (II) some special significance in regard to the distribution of covalency electrons which is no part of the usual conventional meaning of the symbol. It will accommodate *any* such distribution of six covalency electrons which fulfils the requirements of symmetry. The formula represents only the mean position in space of the atoms (kernels) and the mode of binding (that is, the structure disclosed by analysis, synthesis, X-ray crystal evidence, etc.).

It is a further step to the space models which again concentrate attention on the atoms rather than on the distribution of valency electrons. We know that the environments of the carbon atoms in cyclopropane derivatives are tetrahedral (not, usually, *regular* tetrahedral), and this is true whether the valencies are trigonal or not. Incidentally, Dr. Walsh says that the atoms are *near*-trigonal, but that would appear to mean tetragonal, although of a very distorted type. The formula (II) is, therefore, entirely satisfactory unless we read more into it than was ever intended. On the other hand, (I) is unsatisfactory because its more important implications are lost on hybridization. It suggests that the carbon atom at the business-end of the arrow is negatively charged; this is not true of the hybrid. It suggests that this carbon atom makes no valency-electron contribution to the bond; again this is not true of the hybrid. It is obvious that any reaction-type implications of (I) are also lost on hybridization. Why should we adopt a formula, each unique feature of which is destroyed by mental reservations, or by the clumsy device of writing three symbols?

Dr. Walsh now finds that the wave-mechanical picture of ethylene oxide allows of *some* resemblance to acetaldehyde. I can only repeat that the chemical resemblance is very close indeed, that the analogy with ethylene is non-existent, and the parallel with amine-oxides is exiguous. The reaction encountered by Karrer[3] is readily explicable by reduction to a tertiary alcohol, a type of process that I mentioned previously[2]. In the presence of an acid catalyst such a substance would suffer dehydration with great facility, especially in these instances where the product is so fully conjugated. This example was naturally not mentioned by me because it is far from representative. If ordinary ethylene oxides were analogous to amine oxides, they should be convertible to ethylenes by mild reducing agents, and that is certainly not the case.

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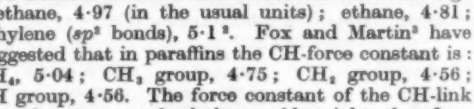
[1] Walsh, *Nature*, **159**, 712 (1947).
[2] Robinson, *Nature*, **159**, 400 (1947).
[3] Karrer, *Helv. Chim. Acta*, **28**, 474 (1945).

Structure of Ethylene Oxide and Cyclopropane

A. D. WALSH[1] has suggested that the properties of cyclopropane and ethylene oxide are better accounted for by the formulæ I (three equivalent resonance forms) and II than by III and IV:



I II III IV

One consequence of this suggestion is that, in the CH-bonds, the carbon orbitals should be of the sp^2 hybrid type, rather than the sp^3 hybrid suggested by III and IV. In 1945 I obtained the force constants of a number of CH-bonds and found the following: methane, 4·97 (in the usual units); ethane, 4·81; ethylene (sp^2 bonds), 5·1[2]. Fox and Martin[3] have suggested that in paraffins the CH-force constant is: CH_4, 5·04; CH_3 group, 4·75; CH_2 group, 4·56; CH group, 4·56. The force constant of the CH-link in cyclopropane and ethylene oxide might, therefore, prove valuable in deciding between the above structures.

From the Raman[4] and infra-red[5] spectra of cyclopropane it has been decided that the CH-valency vibration frequencies are: A_1', 3,000; E', 3,000; A_2'', 3,050; E'', 3,080 cm.$^{-1}$. The derived force constants are: 5·04, 5·04, 4·91 and 5·02. The mean is 5·0. (The same values of the fundamental constants have been used as in my previous paper[2].) The Raman[4] and infra-red[5] spectra of ethylene oxide indicate that the CH-valency vibration frequencies are A_1, 3,000; B_1, 3,000; B_2, 3,062; A_2, 3,062 cm.$^{-1}$. The derived force constants are 5·04, 5·04, 4·95 and 4·95. The mean is again 5·0. Ethylene sulphide is also of interest. Thompson and Dupré, having examined the Raman and infra-red spectra, suggested for the CH-valency vibrations: A_1, 2990; B_1, 2,990; A_2,

3,080; and B_2, 3,080 cm.$^{-1}$ [6]. The derived force constants are 5·00, 5·00, 5·02 and 5·02. The mean may be taken as 5·0. In all these three compounds the CH-force constant is 5·0.

For the CH-bond in a methylene group in an ordinary paraffin chain, we would expect the force constant to be about 4·6 (Fox and Martin), and certainly not greater than 4·8 (CH_3-group). The force constant in the methylene groups in these ring compounds is certainly significantly greater than this. It is, moreover, nearer the ethylene figure of 5·1 than to the figure for a methylene group in a paraffin. (It seems proper to make the comparison with the CH_3-group in a paraffin chain, though it may be noted that the CH-force constant in these ring compounds is not appreciably different from that in methane itself.) The conclusion to be made from these calculations must be that the force constants indicate that the CH-links in these ring compounds approach those in ethylene. So the calculations provide a measure of support for Walsh's suggestion. Of course, the CH-force constant might change simply as a result of the distortion in the angle between the bonds which form the ring. However, such a change is hypothetical, and it is, therefore, rather unsatisfactory as an explanation of these results.

The possible usefulness of the above calculations became apparent to me after hearing a lecture by Dr. Walsh on this and related topics.

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[2] Linnett, *Trans. Farad. Soc.*, **41**, 223 (1945).
[3] Fox and Martin, *Proc. Roy. Soc.*, A, **175**, 208 (1940).
[4] Ananthakrishnan, *Proc. Ind. Acad. Sci.*, **4**, 82 (1936).
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[6] Thompson and Dupré, *Trans. Farad. Soc.*, **36**, 805 (1940).

Fluorescence 'Fatigue'

Use of the term fluorescence 'fatigue'[1] to describe the decrease in fluorescence which is observed in many substances on continued irradiation, both in the solid state and in solution, is to be deprecated as it naturally implies something analogous to the well-known phenomenon of elastic fatigue; or to muscular fatigue. It is scarcely conceivable that any process at all comparable with either type of fatigue can occur in the case of a fluorescent molecule, particularly in dilute solution, and the only satisfactory explanation of any observed change of fluorescence with time of exposure to the exciting radiation, at any rate in dilute solution, is that photochemical changes occur which result in a change in the concentration of the molecular species responsible for the fluorescence. Recently published work[2] on the photochemical instability of stilbamidine made extensive use of the brilliant fluorescence of the *trans*-form of this compound to elucidate the nature of the photochemical changes which occur, and the above view is certainly amply justified in this case, the changes being concurrent dimerization and *trans-cis*-isomerization in proportions depending on concentration and temperature.

Neither *cis*-stilbamidine nor the product of the dimerization of *trans*-stilbamidine exhibits any fluorescence in the visible spectrum, but appropriate irradiation of solutions of these compounds results in a steady *increase* from zero in the intensity of fluorescence. This development of fluorescence on continued irradiation has been shown to be due, in each case, to partial conversion of the compound into *trans*-stilbamidine. The changes in fluorescence which solutions of these compounds exhibit on irradiation can therefore be explained completely in terms of the photochemical changes which occur. If the fading of the fluorescence of a solution of *trans*-stilbamidine on irradiation is to be attributed to a fluorescence 'fatigue', to what effect is the increase of the fluorescence of solutions of *cis*-stilbamidine and the dimer to be ascribed?

The change which the fluorescence of a solution of riboflavin undergoes on irradiation can also be quite adequately explained in terms of the photochemical changes which occur. This can be readily demonstrated by spotting-out the solution on filter-paper after varying periods of irradiation, washing radially[3] with water and examining the dry filter-papers in ultra-violet light. The steady disappearance of riboflavin from the solution, and the steady formation of a substance with a bluish fluorescence and greater adsorbability on filter-paper than that of riboflavin, which enables separation of the two compounds to be effected, is immediately apparent.

The importance in fluorimetric analysis of the dependence of fluorescence intensity upon time of irradiation is, of course, fully appreciated. The large effect on fluorescence which change of temperature sometimes produces must also not be overlooked. This is probably due in the main to modification of the course of some photochemical change which the fluorescent compound undergoes. Recovery of fluorescence on discontinuing irradiation can be attributed to reversal of a photochemical change taking place as a dark reaction.

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April 19.

[1] Alper, T., *Nature*, **158**, 451 (1946).
[2] Henry, A. J., *J. Chem. Soc.*, 1156 (1946).
[3] Henry, A. J., and Grindley, D. N., *Ann. Trop. Med. Parasit.*, **39**, 1 (1945).

The Name of Element 23

Prof. F. A. Paneth[1] has made certain suggestions in connexion with the naming of new elements. We quote the following: "(1) The right to name an element should go to the first to give definite proof of the existence of one of its isotopes. . . . (3) If a claim to such a discovery has been accepted in the past, but is refuted by later research, the name given should be deleted and replaced by one chosen by the real discoverer."

These rules seem to apply fittingly to the case of element 23, at present called vanadium, to which we wish to direct attention. The facts relating to its discovery, so far as known to us, are as follows.

In 1801 Andrés Manuel del Río, professor of mineralogy at the Royal School of Mines of Mexico, thought he had found in ores from Zimapán, Hidalgo, Mexico, a new element which he named 'erythronium'. He published his findings in "Tablas Mineralógicas" in 1804 [2]. In 1802 del Río gave samples containing the new element to Alexander von Humboldt, taking advantage of the latter's visit to Mexico[3]. Von Humboldt took these samples with him to Paris on

his return to Europe and gave them to M. Collet-Descotils, asking for a report on del Río's claim. Collet-Descotils analysed del Río's samples and reported—erroneously—that they contained only chromium[4]. At that time von Humboldt accepted this verdict and therefore rejected del Río's claim as invalid.

The facts relating to Sefström's discovery of vanadium in 1830, and to Wöhler's work[5] establishing the identity of 'erythronium' and vanadium, are well known. Here we would only like to add that in 1831 both Berzelius[6] and von Humboldt[7] recognized del Río's priority as valid.

As a consequence of a conversation held between del Río and von Humboldt, the former gave up temporarily his claim to the discovery of a new element, accepting that what he had really found was chromium[8]. He held to this point of view after the publication of Collet-Descotils' error[9].

From the preceding historical facts, it follows that the real priority for the discovery of element 23 belongs to Andrés Manuel del Río. Our main purpose is to emphasize that under the rules suggested by Prof. Paneth, del Río's choice for the name of this element should stand. Element 23 should, therefore, be called 'erythronium' and not vanadium. Whether this change in accepted chemical nomenclature of long standing is at all possible is here neither implied nor suggested. Paneth's rules, however, either should be applied uniformly to all cases they are meant to cover, or to none at all.

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May 15.

[1] Paneth, F. A., *Nature*, **159**, 8 (1947).
[2] "Tablas Mineralógicas", by D. L. G. Karsten, translated into Spanish by Andrés Manuel del Río, footnote pp. 61–62, México, Zúñiga y Ontiveros, 1804.
[3] Letter addressed to Baron Alexander von Humboldt by Andrés M. del Río, dated October 14, 1817, published in *Mercurio de Espana*, p. 173, Madrid, February 1819.
[4] Collet-Descotils, M., *Annales de Chimie*, **53**, 254–258 (1805).
[5] von Hoffmann, A. W., Briefwechsel zwischen J. von Liebig und F. Wöhler, *Kongl. Sv. Vetensch Acad.*, **1**, 38–39 (1831); also *Poggendorfs Annalen der Physik und Chemie*, **21**, 49 (1831).
[6] Berzelius, J., *Annalen der Physik und Chemie*, **22**, 1–67 (1831).
[7] von Humboldt, A., Révue bibliographique pour servir de complément aux *Annales de Sciences Naturelles* par M. M. Audonin, Brongniart et Dumas, 2eme. année, pp. 42–43 (1831).
[8] *Anales de Ciencias Naturales*, **19**, 31 (Madrid, Feb. 1804).
[9] *Diario de México*, **15**, No. 2170, 294–295 (México, Sept. 11, 1811). *Mercurio de Espana*, 172–175 (Madrid, Feb. 1819). *Annalen der Physik von Gilbert*, **71**, 7/12 (1822).

The foregoing letter may create the impression that Del Río only "temporarily" abandoned his claim to the discovery of erythronium, misled by "Descotils' error" and Humboldt's persuasion. This, however, is not the story he himself tells in his last contribution to the subject[1]. In discussing the chemical composition of the Zimapan lead ore, he not only stresses the point that it contains no other element than the lead chromates, but ascribes to himself the merit of this 'discovery'. He states that he had published the correct analysis one year before Descotils, and attacks Humboldt for intentionally suppressing this fact and giving credit to a French chemist out of spite against the Spanish. Not a single word is said about the old erythronium claim, which he seems very anxious to consign to oblivion.

The rule suggested says that the right to name an element should go to the first to give *definite* proof of its existence. It is difficult to see how Del Río could be included under this heading, in view of his quick, complete and lasting change of front—even if we may have some doubts whether his recantation actually preceded the Paris analysis, as he so emphatically claims.

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[1] *Gilbert's Ann. der Phys.*, **71**, 7 (1822).

Naming the Elements: a Former Suggested Use of 'Plutonium'

In view of the recent naming of new elements, the following two quotations, which have lately come to my notice, may interest or amuse historians of science. They refer to an early *claim* that barium oxide can be reduced by the oxyhydrogen blowpipe. In Thomas Thomson's famous "System of Chemistry" (5th edit.; London, 1817), vol. 1, p. 342, we read: "Dr. Clarke has decomposed barytes by exposing it to an intense heat, produced by the combustion of a stream of oxygen and hydrogen gas, mixed together in the requisite proportions to form water. He has given to the metal of barytes the name of *plutonium*." It appears that, in this quotation, "barytes" means barium oxide and not the sulphate, as now (see below).

Edward Daniel Clarke (1769–1822) was, from the end of 1808 until his death, professor of mineralogy at Cambridge—he was the first occupant of the chair—and his life, travels and work are duly recorded in the "Dictionary of National Biography". Again, in the "Life and Remains of Edward Daniel Clarke" by the Rev. W. Otter (London, 1825), vol. 2, p. 455 (footnote), we read (Dr. Clarke speaking; date 1819): "In proposing the substitution of Plutonium, instead of Barium, for the name of the metal of Barytes, the author was actuated solely by a regard to truth, as essential to science. The impropriety of naming one of the lighter metals, from βαρὺς signifying *heavy*, will surely be obvious, when it now appears that the name implies an untruth. The specific gravity of the metal of Barytes equals 4·000. With what propriety, therefore, can it be denominated Barium, the heavy metal? . . . The metal of Barytes, in whatsoever manner its presence may be demonstrated, owes all the proofs of its existence to the dominion of fire; hence the propriety, at least, of giving to it the name of Plutonium." Incidentally, the modern value for the specific gravity of metallic barium is 3·78.

In 1774, Scheele discovered a new earth in native manganese dioxide (which often contains barium as an impurity), and Gahn in 1775 found that this earth is a constituent of 'heavy spar' ($BaSO_4$). It seems that the *earth* was called 'barote' by Guyton de Morveau, 'barytes' by the Irish chemist, Kirwan, and 'baryta' by Lavoisier. Barium was isolated electrolytically by Davy in 1808.

As history would have it, Davy's name, 'barium', for the metal remained, in spite of Clarke's ingenuous logic; but we may now hail the unexpected return to the service of science of its former rejected rival.

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FULMER RESEARCH INSTITUTE

By E. A. G. LIDDIARD
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THE opening of the Fulmer Research Institute at Stoke Poges, Bucks, by Sir Stafford Cripps (see p. 150) marks the beginning of a new experiment in industrial research, the progress of which should be followed by all who are interested in the organisation of research in Great Britain. Briefly, the object of the Fulmer Research Institute, Ltd., is to provide research facilities which can be used to carry out research privately for any sponsor, or group of sponsors, the results arising from the research remaining under the control of the people who pay for the work. Its closest parallel is in the Battelle Memorial Institute or the Mellon Institute in the United States.

The suggestion has often been made, both in the editorial columns of *Nature* and elsewhere, that there is room in Great Britain for this type of research institute. This opinion is not invariably accepted, particularly by strong supporters of the research association movement, on the erroneous assumption that such an institute would compete with research associations. At the moment, fundamental research work in Britain is mainly carried out at the universities, and industrial research work either by the private laboratories associated with the works of individual firms or by research associations. Research associations have been particularly successful in solving problems which are common to all sections, and in educating industry in the scientific methods of approach to their problems. They also provide an excellent pool for the exchange of technical information which benefits the industry as a whole. The research associations have the advantage that the cost of researches is borne by many subscribers whose individual contributions are small in relation to the cost of the researches, and much more work can therefore be done than would be possible if the research work was left to be financed by the individuals concerned. The Department of Scientific and Industrial Research grant and the freedom they enjoy from rates and taxes put the research associations in a favourable financial position.

The limitation of a research association, however, lies in the absence of any mechanism for developing really new, original and individualistic ideas. The most advanced firms in any industry are not often prepared to put forward their very brightest ideas for the research association to work upon for the benefit of the whole industry. Research programmes of research associations are usually arranged on democratic lines by committees representing the industry, which restricts the activities of the research associations to problems in which the majority of the industry is interested but which are either beyond the resources of an individual member or are not considered to be sufficiently urgent or important to take up the time of the research department of individual members.

What, then, is the position of a concern wishing to develop an original idea or a new process of manufacture to help it to compete successfully in the world's markets? In the absence of an institute where sponsored research is carried out confidentially, the choice lies between making the idea and the results of any research work on the idea generally known, when it becomes of equal value to competitors, or of collecting together the necessary specialized staff and equipment to do the work in its own laboratories. This entails considerable capital outlay, and, when the work is completed, the profitable use of the staff and equipment may present a difficult problem.

There remained, therefore, an important gap in our organisation of research, and in filling that gap there is no question of competition between an institute for sponsored research and a research association.

In the situation in which Great Britain finds itself to-day, we are told that we must export. Some of the most important assets of the country are the brains and ideas of its scientific workers; these are at present mainly being used for the provision of knowledge which is available to the world at large. For pure scientific work this arrangement is ideal, but we are living in a competitive age, and it would seem to be common sense to do all we can to capitalize in the national interest our assets in the form of applied science. This can only be done effectively if the results of research remain in the hands of people capable of making full use of them. For example, a new process which may follow from research at a university becomes available equally all over the world, and is everybody's or nobody's property; in fact, research work done in Great Britain has often been applied abroad before it is used at home. But where the results of research work are owned by an individual sponsor, any process arising from them can be used to increase our exports or, if patentable or negotiable, can result in increased national income from royalties, etc.

The Fulmer Research Institute aims eventually at carrying out research in a wider field, but to begin with, will concentrate on metallurgical and allied problems. Equipment and staff will be available to tackle most forms of metallurgical research, and work may be placed there in the knowledge that the results will be treated confidentially and that they may be exploited by the sponsor for his sole benefit. Provision has been made whereby nominees of the people who sponsor a research can come to work in the laboratories on the development of new industrial processes and can go back to the sponsor when the work is completed, carrying with them the knowledge that they have gained in the laboratories.

The idea of such an Institute was conceived by Colonel W. C. Devereux, who, having studied the system of sponsored researches in operation in the United States at the Battelle and Mellon Institutes, became convinced that a similar institution is needed in Great Britain. The Fulmer Institute is non-profit-making, in the sense that there will be no distribution of dividends. Charges for research are based on cost of salaries and materials, plus a small margin which will be available for the future expansion and further equipping of the Institute. Work is not undertaken on one problem for more than one sponsor unless the original sponsor agrees to share both the cost and the results of the research. Publication of the research results will be at the discretion of the sponsor; but the Institute will advise publication wherever practicable, particularly where the results of the research can be covered by patents which, of course, become the property of the sponsor.

The size of the Institute can be assessed from the fact that the total floor area is approximately 20,000 sq. ft. Chemistry, corrosion, vacuum, engineering, physics and metallography sections are housed in the main building (a converted country

mansion), together with the library, offices and canteen. A new building contains the machine shop and the experimental casting and heat-treatment laboratories. Twelve out of a total staff of forty are graduates, and the staff includes chemists, physical chemists, physicists and engineers as well as metallurgists.

The most important researches at present in progress are in the development of new alloys for service at high temperatures; researches on aluminium base alloys (these are in charge of Dr. A. H. Sully); and on a process for refining impure aluminium by catalytic distillation based on the existence of monohalides of aluminium stable at low pressures and high temperature which can be formed by passing the normal trivalent halides over aluminium at high temperatures and low pressures. They decompose to the metal and the trivalent halide at lower temperatures. This work is being carried out by a team under the direction of Dr. P. Gross. The principle is likely to be applicable to other metals, and sponsorship for researches on the refining of other metals on this principle is sought.

Although the Institute is prepared to consider any type of research work, the staff and equipment are such that problems in physical metallurgy, corrosion and finishing, the development of new casting processes and in the application of thermodynamics to metallurgical problems are likely to be tackled most successfully.

A certain proportion of short-term work involving mechanical and analytical testing and advice and information on technical problems is also undertaken and constitutes an important but not a major part of the Institute's activities.

SURFACE TENSION IN LIQUIDS

By C. GURNEY

THERE is ample experimental evidence that the free surface of liquids is in a state of tensile stress, but this stress has never been satisfactorily explained in terms of the positions and motions of molecules. It is generally recognized that liquids cannot permanently withstand shear, and yet a two-dimensional tensile stress implies shear in all planes inclined to the plane of the tension. How is this possible? The most acceptable previous explanation is that due to Bakker[1], which has recently been discussed by R. C. Brown[2]; but the Bakker theory is not very satisfying, as it is an attempt to show that the surface of a liquid could be in a state of effective tensile stress without an associated shear stress. The failure to explain the tension stress in the surface of liquids has led many writers to regard it as unreal. Authors who have referred to the stress as a 'fiction' include Laplace, Rayleigh and N. K. Adam. Adam[3] also writes, "The surface tension does not exist as a physical reality". J. Rice[4], in his commentary on Gibbs' papers on surface phenomena, is at pains to absolve Gibbs from having the notion that the surfaces of liquids are in a state of tension stress.

By giving a molecular interpretation to the thermodynamics of surfaces as developed by Gibbs, I give below what seems to be a satisfying explanation of the tension stress in the planes of surfaces, and which appears to have some novel features. Gibbs introduced into thermodynamics a quantity (μ) which he called the intrinsic potential of a substance. Subsequent authors have called this quantity partial molal free energy, chemical potential, etc. For equilibrium between phases and between each part of a heterogeneous phase, Gibbs showed that the intrinsic potential of the parts of each component substance must have the same value throughout the system. The intrinsic potential is a measure of the escaping tendency of molecules. Molecules tend to escape from regions of high μ and to migrate to regions of low μ. Equality of the intrinsic potentials ensures that just as many molecules of each species enter each region as leave it. This condition is therefore similar to the equation of continuity in fluid mechanics; but in thermodynamics we are dealing with random motion of molecules, whereas fluid mechanics deals with organised motion. At a given temperature, intrinsic potential depends on the arrangement and relative position of molecules. Molecules at a free surface or at an interface between two different substances have a different environment from interior molecules, and they would, therefore, be expected to have different intrinsic potentials, whereas for equilibrium they must have the same intrinsic potential as interior molecules. How then can equilibrium be achieved? At this stage it may be helpful to consider another case of thermal equilibrium.

Consider a pure substance, say lead, in equilibrium with its liquid. When stress-free, there is only one temperature at which this equilibrium can occur. At this temperature the intrinsic potentials of solid and liquid are equal. At room temperature, solid lead has the smaller μ, and in consequence the solid phase is stable. How could we have solid and liquid lead in equilibrium at room temperature? The answer is that stress must be applied to the solid or liquid or both, until their intrinsic potentials are equal. In principle at least we could apply pressure to the solid to increase its intrinsic potential to that of the stress-free liquid, or we could apply hydrostatic tension to the liquid to decrease its intrinsic potential to that of the stress-free solid. For two-phase equilibrium there is thus a relationship between stress and temperature. By making use of the relationships

$$\frac{\partial \mu}{\partial p}_{Tn} = \bar{v} \text{ and } \frac{\partial \mu}{\partial T}_{pn} = -\bar{s}, \quad . \quad . \quad (1)$$

(where p, T, and n are pressure, temperature, and quantity of substance respectively and $\bar{v}$ and $\bar{s}$ are specific volume and specific entropy), the relationship between p and T for the case in which the liquid only is subjected to pressure is

$$\frac{dp}{dT} = \frac{L}{T\bar{v}}, \quad . \quad . \quad . \quad (2)$$

where L is the latent heat of the solid-liquid transition. The equilibrium pressure on the liquid thus increases with temperature; at low temperatures (below the stress-free melting point) the equilibrium pressure is negative. In principle, therefore, we could have solid and liquid lead in equilibrium at room temperature by applying a hydrostatic tension to the liquid.

It is now only a small step to the explanation of the tension in the free surface of a liquid. In the absence of stress, surface molecules have a higher μ than interior molecules. For equilibrium, stress must be applied to the surface or interior or both, to make the intrinsic potentials of surface and interior molecules equal. As the surface molecules have the higher μ, it is easy to see, by analogy with the solid-liquid equilibrium case, that the stress which must

be applied to maintain equilibrium is a tension in the plane of the surface. The thermodynamic relations are

$$\frac{\partial \mu}{\partial \gamma}_{Tn} = -\overline{A} \text{ and } \frac{\partial \mu}{\partial T}_{\gamma n} = -\bar{s}, \quad . \quad (3)$$

where γ is the surface tension, $\overline{A}$ is specific area and $\bar{s}$ is the specific entropy of the surface. The relationship between surface tension and temperature is

$$\frac{\partial \gamma}{\partial T} = -\frac{L}{T\overline{A}}, \quad . \quad . \quad . \quad (4)$$

where L is the latent heat of the liquid-surface transition. The difference in sign of expressions 2 and 4 is due to the fact that tension and pressure must be considered to be of opposite sign. The expressions are similar because the tension stress in the surface of a liquid is there for the same reason as would be the hydrostatic tension on a liquid in equilibrium with its solid, at a temperature below the stress-free melting point. The tensions are necessary to reduce the intrinsic potentials of the surface in the one case, and the liquid in the other, so that they equal the intrinsic potentials of the adjacent phases.

A more detailed picture of how the tension stress reduces the intrinsic potential of surface molecules may be obtained as follows. When a molecule escapes from the surface of a liquid, the neighbouring surface molecules move so as to fill up the hole which would otherwise be left by the escaping molecule. The area of the surface is thus reduced by the effective area of the escaping molecule. If acting in the plane of the surface, there is a constant tension force (γ); work must be done against this force which equals γA, where A is the effective area of a molecule. At the same time, the strain energy associated with the molecule is lost. This amounts to $\int_{A_0}^{A} \gamma dA$, where A and A_0 are the effective areas occupied by a molecule when the surface is under tension γ and zero force respectively. The net work done by the tension in the plane of the surface when a molecule escapes from the surface is therefore

$$-\gamma A + \int_{A_0}^{A} \gamma dA = -\int_{0}^{\gamma} A d\gamma. \quad . \quad . \quad (5)$$

The right-hand side of this expression when differentiated and computed per unit mass instead of per molecule is equal to $-\overline{A}$, which by the first of equations (3) is equal to $\partial\mu/\partial\gamma$. The tension in the surface, therefore, reduces the intrinsic potential of the surface, because of the work done against the tension when a molecule escapes from the surface.

For substances in which the range of molecular action exceeds the effective dimensions of a molecule, the intrinsic potential of molecules near, but not actually in, the surface would exceed that of interior molecules, and some tension force (although it will be much smaller than that necessary between the outermost molecules) will be necessary to reduce their μ to that of interior molecules. The surface tension must thus be regarded as acting over a region a few molecules thick, the intensity of the force decreasing rapidly with increasing distance from the surface.

We are now in a position to discuss how the tension is set up and maintained. Imagine a stress-free surface of given area. The μ of surface molecules is higher than that of interior molecules. More molecules, therefore, leave the surface than enter it, so that fewer molecules are left to occupy the given area of surface. Their spacing in the plane of the surface therefore exceeds the stress-free spacing, and a tension stress is set up between them. Molecules continue to leave the surface until the tension stress is increased to that necessary to equalize the intrinsic potentials of surface and interior molecules. At this stress, equilibrium is attained, and just as many molecules enter the surface as leave it. The equilibrium tension is then automatically maintained. There is no need to postulate any special orientation of surface molecules or to try to show that there is no shear stress associated with the tension. The tension stress in the surface is continually trying to relax, but as fast as it does so the μ of surface molecules is increased, and then more molecules leave the surface than enter it until the surface is tightened up. If for any reason the tension became too high, the intrinsic potential of the surface would be too low, and more molecules would enter the surface than leave it, until the tension in the surface was slackened off. This is a fascinating process. In the plane of the surface of a liquid so mobile that millions of molecules per square centimetre are entering and leaving the surface per second, there exists a tension force which cannot relax.

[1] Bakker, G., "Wien-Harms Handb. Exptphys.", **6** (1928).
[2] Brown, R. C., *Proc. Phys. Soc.*, in the press.
[3] Adam, N. K., "The Physics and Chemistry of Surfaces" (Oxford Univ. Press, 1941), 5.
[4] Rice, J., "Commentary on the Scientific Writing of J. W. Gibbs" (Yale Univ. Press), **1**, 505.

INTRODUCTION OF NEW ELECTRICAL AND LIGHT UNITS

SIR CHARLES DARWIN, director of the National Physical Laboratory, has issued the following announcements with regard to the introduction of new electrical and light units, in accordance with the decisions taken by the International Committee of Weights and Measures at its meeting in Paris in October 1946.

Electrical Units

The system of electrical units employed at present at the National Physical Laboratory are the 'international' units, which are based on certain material standards. From January 1, 1948, the units employed will be those derived from the centimetre, gram and second, that is, the so-called 'absolute' units. The effects of this change may be seen from the following table:

1 international ohm	= 1·00049	'absolute' ohms	
,, volt	= 1·00034	,,	volts
,, ampere	= 0·99985	,,	ampere
,, watt	= 1·00019	,,	watts
,, henry	= 1·00049	,,	henries
,, farad	= 0·99951	,,	farad

The factors given in this table apply to the mean international units; that is to say, to the mean values of the international units as realized at the various national laboratories.

After January 1, 1948, apparatus submitted to the Laboratory with the view of the issue of a National Physical Laboratory Certificate of Examination will be regarded as acceptable if its errors fall within the specified limits when the values are expressed in either international or absolute units, provided that it was

manufactured before January 1, 1949, and is marked accordingly. Apparatus manufactured after that date, and any apparatus not marked with the date of manufacture, will be acceptable only if its errors fall within the specified limits when the values are expressed in absolute units.

Unit of Light

The National Physical Laboratory will, on and after January 1, 1948, express all photometric values in terms of units based on the 'new candle'. This unit of luminous intensity is of such a magnitude that the brightness of a full (or cavity) radiator (black body) at the temperature of solidification of platinum is 60 'new candles' per square centimetre. The 'new lumen' is the luminous flux radiated within unit solid angle by a uniform source having a luminous intensity of one 'new candle'. The new unit of illumination will be one 'new lumen' per unit area. One 'new lumen' per sq. ft. will also be called one 'new foot-candle', and one 'new lumen' per sq. metre one 'new lux'. The new unit of brightness will be one 'new candle' per unit area, and, alternatively, one 'new foot-lambert'. The latter unit is defined as the brightness of a perfectly diffusing surface of 100 per cent reflexion factor when its illumination is one 'new lumen' per square foot.

When differences of colour are involved in the determination of any magnitude in terms of the above units, the evaluation will be in accordance with that which would be obtained by an observer having the relative luminosity curve (the curve connecting eye sensitivity with wave-length) adopted by the International Commission on Illumination in 1924 and later by the International Committee of Weights and Measures.

The differences between the new units and those in use hitherto are small. The present units, based on the 'international candle', were introduced on April 1, 1909, in Great Britain, France and the United States of America, and were adopted in 1921 by the International Commission on Illumination. Nevertheless, Germany and some Central European countries continued to use units based on the Hefner candle (about 0·9 international candle). The international candle was not based on any primary standard; it was derived from the units defined in terms of the old flame standards, and was maintained by means of carbon and tungsten filament electric lamps. Further, the values of the unit at different colour temperatures did not exactly agree, when compared on the basis of the international relative luminosity curve adopted in 1924.

The magnitude of the new unit has been so chosen that it will introduce only very small changes (less than 0·5 per cent) in the values of luminous intensity assigned to lamps operating at a colour temperature of about 2,360° K. For lamps at considerably higher colour temperatures, for example, ordinary gas-filled electric lamps at normal efficiencies, the values expressed in terms of the 'new candle' will be several per cent lower than those expressed in international candles. At the colour temperature of the primary standard (2,046° K.), values in terms of the 'new candle' are about 1·7 per cent higher than those in terms of the international candle.

On account of this alteration in the basis on which sources of light of different colours are compared, it is impossible to give a factor for converting values in international candles to values in 'new candles'.

U.S. NATIONAL ACADEMY OF SCIENCES

Elections and Awards

AT the annual meeting of the U.S. National Academy of Sciences held in Washington during April 28–30, the following officers, members, and foreign associates were elected:

President (July 1, 1947–June 30, 1951): Alfred N. Richards, vice-president in charge of medical affairs, University of Pennsylvania (in succession to Dr. Frank B. Jewett).

Home Secretary (re-elected for a further term of four years ending June 30, 1951): F. E. Wright, Carnegie Institution of Washington, Washington, D.C.

Members of the Council of the Academy (for a three-year term ending June 30, 1950): W. Albert Noyes, jun., chairman, Department of Chemistry, University of Rochester, Rochester, N.Y.; and Donald D. Van Slyke, chief chemist, Hospital of the Rockefeller Institute for Medical Research, New York City.

Members: Luis W. Alvarez, professor of physics, University of California, Berkeley, California; Robert F. Bacher, U.S. Atomic Energy Commission, Washington, D.C.; Paul D. Bartlett, professor of chemistry, Harvard University, Cambridge, Mass.; Jacob Bjerknes, professor of physics, University of California at Los Angeles, California; Francis G. Blake, dean of Yale University School of Medicine, New Haven, Conn.; R. Alexander Brink, chairman of the Department of Genetics, University of Wisconsin, Madison, Wisconsin; Ralph W. Chaney, professor of paleobotany and curator of paleobotany, Museum of Paleobotany, University of California, Berkeley, California; Arthur C. Cope, professor in charge of the Department of Chemistry, Massachusetts Institute of Technology, Cambridge, Massachusetts; Farrington Daniels, professor of physical chemistry, University of Wisconsin, Madison, Wisconsin; Arnold Gesell, director, Clinic of Child Development, Yale University School of Medicine, New Haven, Connecticut; James Gilluly, professor of geology, University of California at Los Angeles, California; R. B. Goldschmidt, professor of zoology, University of California, Berkeley, California; Samuel A. Goudsmit, professor of physics, Northwestern University, Evanston, Illinois; C. H. Herty, jun., research engineer and assistant to vice-president, Bethlehem Steel Company, Bethlehem, Pennsylvania; Frederick L. Hisaw, professor of zoology, Harvard University, Cambridge, Massachusetts; Wolfgang Köhler, professor of psychology, Swarthmore College, Pennsylvania; L. G. Longsworth, associate member, Rockefeller Institute for Medical Research, New York City; Edwin M. McMillan, professor of physics, University of California, Berkeley, California; Walter J. Meek, acting dean, Medical School, University of Wisconsin, Madison, Wisconsin; J. L. Oncley, director, Ultracentrifuge Laboratory, Harvard University Medical School, Boston, Massachusetts; Lars Onsager, professor of chemistry, Yale University, New Haven, Conn.; John P. Peters, professor of medicine, Yale University, New Haven, Conn.; Paul A. Smith, professor of mathematics, Columbia University, New York City; C. Richard Soderberg, professor of applied mechanics, Massachusetts Institute of Technology, Cambridge, Massachusetts; Paul Weiss, professor of zoology, University of

Chicago, Chicago, Illinois; F. W. Went, professor of plant pathology, California Institute of Technology, Pasadena, California; Robert E. Wilson, chairman of Board of Directors, Standard Oil Company of Indiana, Chicago, Illinois; E. Bright Wilson, jun., professor of chemistry, Harvard University, Cambridge, Massachusetts.

Foreign Associates: P. A. Alexandroff, professor of mathematics, University of Moscow; K. Linderstrøm-Lang, head of the Chemical Division, Carlsberg Laboratory, Copenhagen; J. N. Brønsted, professor and director of the Institute for Physical Chemistry, Copenhagen; Björn Helland-Hansen, director of the Geophysical Institute, Bergen; F. C. Bartlett, director of the Psychological Laboratory and professor of experimental psychology, University of Cambridge.

Medal Awards

John J. Carty Medal. The John J. Carty Gold Medal and Award for 1947 was presented to Dr. Ross G. Harrison, professor emeritus, Osborn Zoological Laboratory, Yale University, New Haven, Connecticut, for the discovery that tissue cells can be grown outside the animal body, and by the use of this discovery demonstrating the manner of growth of nerve fibres, a fundamental contribution to scientific medicine and biology; for long and distinguished service as investigator, teacher, and counsellor of students; and for statesmanlike direction of the National Research Council during a period in which it played a vital part in the defence of the United States. As a young man at Johns Hopkins he obtained striking experimental results while engaged in the study of the development of the nervous system. Here he first used the method of isolation of embryonic tissues in culture media and gave an ocular demonstration that the nerve fibre grows out from a single cell without the participation of accessory cells. This led to the procedure known as tissue culture, which has since been widely used in the study of the differentiation, growth and behaviour of normal and tumour cells under various conditions outside the body. After retirement from active university work in 1938 Dr. Harrison became chairman of the National Research Council, which post he held until June 30, 1946. The Council has grown in esteem under his leadership, not as an organisational instrument merely, but also as a place where men gather in friendly association to advance common interests.

Provision for the Carty Medal and Award was made by the American Telephone and Telegraph Company in honour of the late John J. Carty, a member of the Academy, as a token of esteem on the occasion of his retirement from active service. Under the terms of the deed of establishment, the award can be made not more often than once in two years. It can be conferred on anyone who in the judgment of the National Academy of Sciences has made noteworthy contributions to the advancement of fundamental or applied science in any field.

Daniel Giraud Elliot Medal. The Daniel Giraud Elliot Medal for 1945 has been awarded to Dr. Sewall Wright, Department of Zoology, University of Chicago, for his fundamental work dealing with the genetics of evolutionary processes; a programme based on work over a long period, including his paper, "The Differential Equation of the Distribution of Gene Frequencies" (*Proc. Nat. Acad. Sci.*, **31**, No. 12; 1945).

Public Welfare Medal. The Public Welfare Medal of the Marcellus Hartley Fund for 1947 has been awarded to Dr. Karl T. Compton, president of Massachusetts Institute of Technology, Cambridge, Massachusetts, for eminence in the application of science to the public welfare, in recognition of his distinguished contributions of an original character to the science of physics, of his long and valuable career in the field of education and of university administration, and of his great service to the Government of the United States both before and during the War as a member of the National Defense Research Committee and as director of the Office of Field Service of the Office of Scientific Research and Development. "It is the purpose of the Public Welfare Medal to mark the appreciation of the National Academy for eminent services to the public, performed without a view to great monetary gains and by methods which in the opinion of the Academy are truly scientific."

Agassiz Medal. The Agassiz Medal of the Murray Fund for the year 1947 was awarded to Felix Andries Vening Meinesz, professor of geodesy and geophysics in the University of Utrecht and president of the Netherlands Geodetic Commission.

Because of the instability of the water-soaked ground in the Netherlands it was not possible to make accurate measurements of gravity there with the older types of instruments. In order to overcome the difficulty Vening Meinesz designed his multiple-pendulum apparatus by which the desired measurements could be made on unstable ground. Prior to this invention attempts had been made to measure gravity at sea, notably by Hecker, but the results had errors ten times greater than was permissible in measurements made on land. As Vening Meinesz's apparatus could be used on a submarine it made possible gravimetric surveys of the different oceans. In 1923, with the help of the Netherlands navy, Vening Meinesz made his first long voyage, going from a home port to the Netherlands East Indies by way of Suez. In subsequent years he made many voyages in the Atlantic, Pacific, and Indian oceans, paying particular attention to the Mid-Atlantic Ridge and the West and East Indian island arcs. By the beginning of the Second World War, 844 observations had been made on Netherlands submarines, and many observations had been made on submarines of other countries. Among the interesting results of the gravimetric surveys was the discovery of strips of ocean bottom with negative anomalies, which in both the East and West Indies coincide with the seismic belts and the deep narrow troughs of those regions. The Mid-Atlantic Ridge is fundamentally different from the great island arcs in that in it there are no strips with negative anomalies. Two other generalizations are that fields of positive anomalies usually coincide with deep basins, and that the anomaly increases positively in going from shallow to deep water off both continental and island coasts.

Besides having made the measurements indicated above and having studied their distribution with reference to relief, seismic, and volcanic features, Vening Meinesz has proposed explanations of the processes operative in the formation of the troughs with the negative anomalies and the faults and folds in adjacent areas, a hypothesis for the explanation of the origin of the continents and ocean basins, and a hypothetical explanation of a postulated rotation of the earth's crust over deeper-seated material. The value of these unique researches in the study of the physical features of the ocean bottom and adjacent land areas is beyond estimate.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned :

TEACHER IN THE MATHEMATICS AND PHYSICS DEPARTMENT—The Principal, Municipal Technical College, Hopwood Lane, Halifax (August 9).

TOPOGRAPHICAL SURVEYORS (4), GEOLOGISTS (2), BIOLOGISTS (2), and a PHYSICIST, to the Falklands Islands Dependencies Survey—The Under-Secretary for the Colonies, Room 2, 3rd Floor, Queen Anne's Chambers, Dean Farrar Street, London, S.W.1 (August 9).

GRADUATE ASSISTANT IN THE DEPARTMENT OF BIOCHEMISTRY—The Administrator, A.G.E. Sanctuary, Radcliffe Infirmary, Oxford (August 9).

SENIOR PRINCIPAL SCIENTIFIC OFFICER (with an Honours Degree, preferably in Mechanical Engineering), and a PRINCIPAL SCIENTIFIC OFFICER (with high Honours Degree in Physics), in the Royal Naval Scientific Service—The Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 1941 (August 11).

LECTURER IN FLIGHT EXPERIMENTS in the Department of Flight—The Registrar, College of Aeronautics, Cranfield, Bletchley, Bucks (August 11).

PSYCHOLOGIST—The Director of Education, Education Offices, Cobourg Street, Plymouth (August 11).

TECHNICAL CHEMIST, and a BACTERIOLOGIST—The Secretary, Hannah Dairy Research Institute, Kirkhill, Ayr (August 15).

ASSISTANT LECTURER IN PHYSICS—The Registrar, The University, Leeds 2 (August 15).

ASSISTANT LECTURER IN MYCOLOGY—The Registrar, The University, Manchester (August 16).

LECTURER IN CROP HUSBANDRY in the Department of Agriculture—The Secretary, The University, Edinburgh (August 17).

SENIOR LECTURER (Grade I) IN CHEMICAL ENGINEERING, a LECTURER (Grade II) IN PETROLEUM PRODUCTION, and an ASSISTANT LECTURER (Grade III) IN BOTANY—The Secretary, The University, Edmund Street, Birmingham 3 (August 18).

LECTURER (temporary) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING, University of Cape Town—The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (August 21).

METEOROLOGICAL OFFICER CADETS (15) in the Department of Industry and Commerce—The Secretary, Civil Service Commission, 45 Upper O'Connell Street, Dublin (August 22).

RESEARCH OFFICER (Physical Chemist), SECTION OF TRIBOPHYSICS, Melbourne—The Secretary, Australian Scientific Research Liaison Office, Australia House, Strand, London, W.C.2, quoting No. 1314 (August 23).

RESEARCH OFFICER, AERODYNAMICS SECTION, Division of Aeronautics, Melbourne—The Secretary, Australian Scientific Research Liaison Office, Australia House, Strand, London, W.C.2, quoting No. 1319 (August 25).

VETERINARY INSPECTORS (about 100) and RESEARCH OFFICERS and ASSISTANT VETERINARY INVESTIGATION OFFICERS (40)—The Secretary, Ministry of Agriculture and Fisheries, 23–25 Soho Square, London, W.1 (August 31).

DEMONSTRATOR IN ANATOMY, a DEMONSTRATOR IN PHYSIOLOGY, a DEMONSTRATOR IN MORBID ANATOMY AND MORBID HISTOLOGY, a LECTURER IN ANATOMY, a LECTURER IN PHYSIOLOGY, and a LECTURER IN BIOCHEMISTRY—The Secretary, Charing Cross Hospital Medical College, 62 Chandos Place, London, W.C.2 (August 31).

TECHNICIANS IN THE DEPARTMENTS OF ANATOMY AND PHYSIOLOGY—The Secretary, Charing Cross Hospital Medical School, 62 Chandos Place, London, W.C.2 (August 31).

PRINCIPAL SCIENTIFIC OFFICER IN THE INTELLIGENCE DIVISION of the Headquarters Office of the Department of Scientific and Industrial Research in London—The Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 1951 (September 1).

HORTICULTURAL OFFICER, and an ASSISTANT HORTICULTURAL OFFICER—The Chief Education Officer (A), Shire Hall, Cambridge (September 12).

LECTURER IN APPLIED CHEMISTRY, with qualifications to teach students taking an Honours Degree in Technical Chemistry—The Secretary, The University, Edinburgh (September 15).

PROFESSOR OF HUMANITY in the United College, St. Andrews—The Secretary, The University, St. Andrews (September 15).

GRADUATE (in metallurgy, chemistry or physics) for work in a laboratory in the London area in connexion with the production of pure iron and associated research—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting 'London'.

SOIL TECHNOLOGIST and SOIL CHEMIST for the Directorate-General of Agriculture, Iraq—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.N.14628.

LECTURER IN THE DEPARTMENT OF PHYSIOLOGY—The Secretary, The University, Aberdeen.

WORKSHOP MECHANIC IN THE DEPARTMENT OF PHYSICS—The Professor of Physics, Queen's University, Belfast.

LECTURER IN THE MATHEMATICS DEPARTMENT—The Secretary, Northampton Polytechnic, St. John Street, London, E.C.1.

SCIENTIFIC ASSISTANTS (with honours degree in agriculture, botany, geography or biochemistry)—The Director, Imperial Bureau of Pastures and Field Crops, Penglais, Aberystwyth.

LABORATORY ASSISTANT with experience of histological technique—The Professor of Physiology, The University, Bristol 8.

PHOTOGRAPHER for medical and scientific work—The Secretary, Physiology Department, School of Medicine, Leeds 2.

BACTERIOLOGIST for provincial diagnostic laboratory of public health in Halifax, Nova Scotia—Dr. E. G. Young, Lister Institute, Chelsea Bridge Road, London, S.W.1.

ASSISTANT EXPERIMENTAL OFFICERS (Chemists, male) IN THE PLANT AND ANIMAL PRODUCTS DEPARTMENT—The Establishment Officer, Imperial Institute, South Kensington, London, S.W.7.

CHAIR OF BACTERIOLOGY in King Edward VII College of Medicine, Singapore—The Director of Recruitment, Colonial Service, 15 Victoria Street, London, S.W.1.

EXPERTS IN (*a*) PREPARATION OF VACCINES (M.N.18172), (*b*) BACTERIOLOGY (M.N.18173), (*c*) ANIMAL HUSBANDRY (M.N.18174), in the Veterinary Department, Government of Iraq—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting appropriate Ref. No.

ASSISTANT LECTURER IN LOGIC AND SCIENTIFIC METHOD—The Secretary, London School of Economics, Houghton Street, London, W.C.2.

UNIVERSITY ASSISTANTSHIP IN THE DEPARTMENT OF BIOCHEMISTRY—The Secretary, The University, Edinburgh.

LABORATORY STEWARD IN THE CHEMISTRY LABORATORIES, and a LABORATORY STEWARD IN THE BIOLOGY LABORATORIES—The Principal, County Technical College, Stoke Park, Guildford, Surrey.

INSPECTORS OF MINES in Tanganyika Territory—The Director of Recruitment, Colonial Service, 15 Victoria Street, London, S.W.1.

PROFESSOR OF PATHOLOGY tenable at King's College, Newcastle-upon-Tyne—The Registrar, University of Durham, 46 North Bailey, Durham.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Annual Report on the Progress of Rubber Technology. Edited by Dr. T. J. Drakeley. (Published for the Institution of the Rubber Industry.) Vol. 9, 1945. Pp. vi + 117. (Cambridge : W. Heffer and Sons, Ltd., 1946.) To Members, 4*s.* 6*d.* net ; to non-Members, 12*s.* 6*d.* net. [32

University of Cambridge. Annual Report of the Observatories Syndicate. Pp. 4. (Cambridge : The University, 1946.) [32

Parliamentary and Scientific Committee. Annual Report, 1946. Pp. 18. Universities and the Increase of Scientific Manpower. Pp. 22. 1*s.* (London : Parliamentary and Scientific Committee, 1946–1947.) [32

British Standard 1339 : 1946. Humidity of the Air : Definitions, Formulae and Constants. Pp. 10. (London : British Standards Institution, 1946.) 2*s.* net. [42

Department of Scientific and Industrial Research : Fuel Research. Technical Paper No. 54 : The Reduction of Smoke from Merchant Ships ; Trials carried out in S.S. *Ocean Vista*, to determine the Effect of Smoke Elimination upon Fuel Consumption. Pp. vi + 39 + 5 plates. (London : H.M. Stationery Office, 1947.) 1*s.* 3*d.* net. [42

'Wellcome' Photographic Year Book, 1947. Pp. 100 + Diary. (London : Burroughs Wellcome and Co., 1947.) 3*s.* 5*d.* [42

The Profession of Naval Architect. Pp. 8. (London : Institution of Naval Architects, 1947.) [62

Broadcasting Stations of the World. Compiled by *Wireless World*. Pp. 48. (London : Iliffe and Sons, Ltd., 1946.) 1*s.* net. [62

University of London : University College. Calendar, Session 1946–1947. Pp. lxii + 374. (London : Taylor and Francis, Ltd., 1946.) [62

Other Countries

South African Archaeological Society. Handbook Series No. 2 : The Loom of Prehistory. By A. J. H. Goodwin. Pp. 152. (Cape Town : South African Archaeological Society, 1946.) Paper, 12*s.* 6*d.* ; cloth, 15*s.* [301

Koninklijk Nederlandsch Meteorologisch Instituut. No. 108, Seismische Registrierungen in De Bilt. 25,1937. Pp. viii + 45. 0.80 fl. 26,1938. Pp. viii + 64. 1 fl. 27,1939. Pp. vii + 25. 1 fl. 28,1940. Pp. ix + 31. 1 fl. 29,1941. Pp. vii + 34. 1 fl. ('s-Gravenhage : Koninklijk Nederlandsch Meteorologisch Instituut, 1939–1943.) [301

Koninklijk Nederlandsch Meteorologisch Instituut. No. 111, Opstellen op Oceanografisch en Maritiem-Meteorologisch Gebied. 3^de, Passaten, Moessons, Enz. Pp. 56. 0.40 fl. 3^de, Koers en gissvaart voor Stroomberekening. Pp. 23. 0.30 fl. 5, Over de fouten bij een Kwikbarometer met vernauwde buis, Indien de Luchtdrukking verandering Ondergaat. Door H. Keyser. Pp. 16. 0.20 fl. ('s-Gravenhage : Koninklijk Nederlandsch Meteorologisch Instituut, 1939–1940.) [301

Koninklijk Nederlandsch Meteorologisch Instituut. No. 106a, Ergebnisse Aerologischer Beobachtungen. 27,1938. Pp. iv + 46. 1.50 fl. 28,1939. Pp. iv + 36. 1.50 fl. 29,1940. Pp. iv + 12. 1.50 fl. ('s-Gravenhage : Koninklijk Nederlandsch Meteorologisch Instituut, 1939–1941.) [301

Koninklijk Nederlandsch Meteorologisch Instituut. No. 119 : Statistics relating to Typhoons from about 3300 Netherlands Ships' Observations (1910–1935). Vol. 1 : Text. Pp. 100. 3.50 fl. Vol. 2 : Illustrations. Pp. iv + 54 plates. 3.50 fl. ('s-Gravenhage : Koninklijk Nederlandsch Meteorologisch Instituut, 1939.) [301

Southern Rhodesia. Geological Survey Bulletin No. 37 : The Geology of the Lower Gwelo Gold Belt. By Dr. F. L. Amm. Pp. vii + 76 + 5 plates. (Salisbury : Government Stationery Office, 1946.) 3*s.* 3*d.* [42

Annual Report of the Board of Regents of the Smithsonian Institution showing the Operations, Expenditures and Condition of the Institution for the Year ended June 30, 1945. (Publication 3817.) Pp. iv + 484 + 80 plates. (Washington, D.C. : Government Printing Office, 1946.) 1.75 dollars. [42

Indian Council of Agricultural Research, Statistical Branch, New Delhi. Functions and Activities. Pp. ii + 17 + 3 plates. (New Delhi : Indian Council of Agricultural Research, 1947.) [62

New Zealand Air Department. Meteorological Observations for 1942. Pp. 62. (Wellington : Government Printer, 1946.) [62

Observatoire de Paris, Section d'Astrophysique, à Meudon. Annales, Tome 8, Fascicule 3 : Réduction de la Göttinger Aktinometrie au Système International et Indices de couleur de 3294 étoiles entre 0° et + 20° de déclinaison. Par Ch. Bertaud. Pp. iii + 40. Annales, Tome 10, Fascicule 1 : Recherches sur Nova Herculis 1934 et contribution à l'étude comparative des principales novae. Par Charles Bertaud. Pp. iii + 234 + 6 plates. Cartes synoptiques de la chromosphère solaire et Catalogue des filaments de la couche supérieure. Par L. d'Azambuja et R. Servajean. Pp. 32. (Meudon : Observatoire de Paris, 1939–1945.) [62